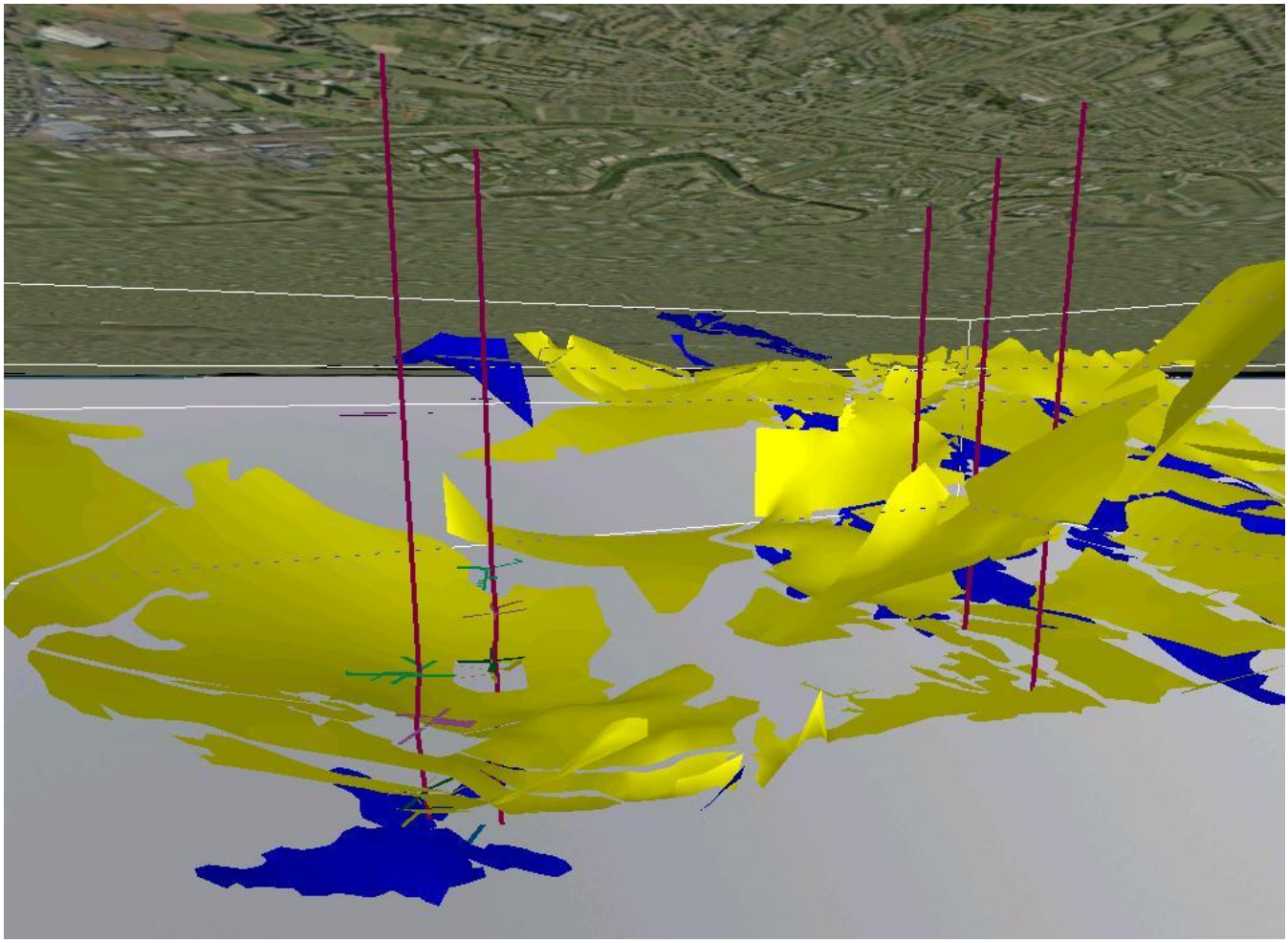
Study into the Potential for Deep Geothermal Energy in Scotland

Scottish Government Project Number: AEC/001/11

Volume 1 of 2



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Deep Geothermal Energy Potential in Scotland

Executive Summary

Executive Summary

The Scottish Government has identified deep geothermal energy as an important emerging renewable energy technology that could have the potential to play a significant role in Scotland's future energy provision.

To date, the extent and location of the potential deep geothermal resources has not been well defined. In addition, potential commercial investment in development of deep geothermal energy requires greater certainty regarding the current administrative framework, including clarification of legal ownership of resources legal ownership, resource licensing, planning and permitting regimes, and financing.

The aim of this study is to identify the steps necessary to take forward the commercialisation of deep geothermal energy in Scotland, including:

- Assessment of the areas most likely to hold deep geothermal resource based on existing geological data sets, and
- Identification of policy options and key actions that can be implemented by the Scottish Government to encourage commercial exploitation of the available geothermal resource.

How Deep is Deep?

There is currently no single agreed or accepted national or international definition of what depth constitutes 'deep' geothermal energy. This is partially due to the wide variations globally in the availability and depth of geothermal resources.

There is a gradation from the near surface, affected by solar radiation, to greater depths that are influenced only by heat from the earth's core ('true' geothermal energy). This study has only directly considered true geothermal energy. Shallow and generally small-scale ground source heat pump (GSHP) developments, which exploit the temperature variation between the shallow sub-surface (which remains relatively constant) and the atmosphere, and extend only to relatively shallow depths, have not been considered.

In considering the requirements for a future potential licensing regime for exploiting geothermal energy, the depth of the resources that it would apply to needs to be considered and a depth of 200m has been recommended as the nominal division between generally shallower GSHP developments and 'deeper' geothermal developments.

The Geothermal Resource

Geothermal energy is the natural heat that exists within our planet. In Scotland there is little direct evidence at the surface of the vast reservoir of stored heat below and geothermal energy has remained largely untapped. Technologies and concepts for exploiting geothermal energy are developing rapidly along two lines: low temperature resources, which exploit warm water in the

relatively shallow subsurface to provide heat either directly (as warm water) or indirectly (via heat exchange systems); and high temperature resources, which yield hot water, usually from greater depths, that can be used to generate electricity.

The geothermal heat resource beneath Scotland can be considered in terms of three main settings:

- abandoned mine workings (low temperature);
- hot sedimentary aquifers (low and possibly relatively high temperature); and
- hot dry rocks / petrothermal sources (relatively high temperature).

a) Abandoned Mine Workings

Scotland's Midland Valley is underlain in many parts by a network of abandoned mines. The now flooded mines could play an important role in future in energy supply, providing access to thermal reservoirs which could help to heat homes and other buildings, and contribute to the energy mix of a low carbon Scottish economy based substantially on renewable energy.

The mine workings have enhanced the permeability of the mined strata such that groundwater can be extracted at a greater rate than would otherwise be possible. The water, and the associated relatively high abstraction rates, provides significant potential for heat exchange, making them potentially suited to large, open-loop ground source heat pump (GSHP) systems. It is estimated that the volume of the mine-worked strata is 600km^3.

The two key parameters which influence the potential for extracting heat from mine waters are the rate at which water can be abstracted from the subsurface without significantly depleting the resource, and the temperature of that water. It is estimated that, with re-injection, the groundwater could be exploited at a rate of 20 to 100l/s/km^2 (litres per second per square kilometre). Recorded mine water temperatures for boreholes in the Midland Valley generally range from 12 to 21°C (mean 17°C). However, this may not accurately reflect the higher temperatures that may occur in some of the deepest mine workings.

It is estimated that some 2.5MW/km^2 (megawatts per kilometre square) could be obtained on average using open-loop ground source heat systems in the mined areas of Scotland. Multiplying this value by the number of square kilometres in the mined area (4.8 x 10^{3}km^2) gives a very approximate estimate of the maximum accessible heat resource of 12GW.

On this basis, mine waters could theoretically provide the equivalent of approximately one third of Scotland's heat demand. The actual contribution is likely to be significantly less because heat cannot be transported efficiently over large distances, a proportion of mine workings will not be suited to heat extraction and low-grade heat delivered by GSHP is most effectively used in well

insulated (typically new-build) properties and existing building stock would likely require extensive upgrading to benefit.

If Scotland were able to access as much of the heat in the mine waters as possible, it may last for approximately 37 years. However, this ignores the reality that additional heat would flow into the mined areas from Earth's interior as well as the limitations on abstraction and use practicalities, meaning that it is unlikely to be possible to access the heat at or even near the maximum possible rate. The resource will therefore last much longer than the above estimate.

Preferred potential locations within the mined areas have not been identified specifically as local economic and technical factors are likely to play a significant role in site selection.

Two existing installations currently tap mine water in Scotland: Shettleston in east Glasgow and Lumphinnans in Fife. Both are small schemes, each serving less than 20 dwellings, and have been operating since approximately 2000. A much larger-scale scheme has been developed utilising water in abandoned mine workings at Heerlen in the Netherlands, funded by the European Commission, and mine water is used for sustainable heating and cooling within the town.

Mine water in abandoned workings in Scotland's Midland Valley therefore presents a potentially important geothermal resource. However, there are many assumptions and generalisations in this assessment and further work is recommended.

b) Hot Sedimentary Aquifers (hydrothermal resources)

Aquifers are bodies of permeable rock that can conduct significant quantities of groundwater. The largest and most conductive aquifers generally occur in sedimentary strata, and any of these that are hot enough and have sufficient productivity to constitute a potential geothermal resource can be termed a Hot Sedimentary Aquifer (HSA). HSA resources are likely to exist, in general, down to depths of around 4km, and most will yield water in the temperature range 20 to 80°C. The hot water can be used for heating, either directly or indirectly (by heat exchange).

Most of Scotland (including much of the Highlands and Southern Uplands areas) is underlain by relatively impermeable rocks, which have no HSA potential. The Midland Valley is the largest onshore part of Scotland to be underlain by sedimentary strata, and the best HSA prospects are likely to be here. However, the Midland Valley is geologically complex, and it can be difficult to make geological correlations between boreholes and to extrapolate surface observations below the ground surface. Interpretation in some areas is complicated further by the influence on groundwater flow of abandoned and active coal mines.

The best HSA prospects in Scotland are probably in the sedimentary strata underlying the northern part of the Midland Valley and the southern onshore margin of the Moray Firth Basin,

and in locally certain strata in parts of south-west Scotland. It is emphasised, however, that current understanding of the distribution and properties of aquifers in Scotland comes very largely from surface and near-surface observations, and relatively little is known about aquifer distributions and properties at depth. The ability of water to move through rocks can change significantly with depth, and testing in deep boreholes will be required to gauge the suitability at depth of any setting with HSA potential.

Relatively high temperatures at the bottom of some coastal boreholes suggest that hot water from offshore sedimentary aquifers may have migrated locally to shallower levels in onshore margins of the aquifers. It may prove possible in some places to access HSA prospects in offshore (near-shore) sedimentary basins by drilling inclined boreholes from onshore coastal locations. It is noted however that such schemes may not be economically viable due to the cost of directional drilling.

c) Hot Dry Rock (petrothermal resources)

In Hot Dry Rock (HDR) resources, heat is extracted from rock at significant depth by fracturing them, injecting cool water into the hot fractured rock, and extracting the resulting hot water. It is noted that HDR is a concept and water may actually be present at depth ('Hot Wet Rock', HWR). These resources are alternatively called 'petrothermal' resources. This requires the development of an Enhanced (or Engineered) Geothermal System (EGS). The EGS concept typically involves developing a 'loop' in the hot rock consisting of boreholes at either end of a network of connected and open induced fractures (enhancement of permeability), through which cold water is introduced and hot water is removed. HDR resources could typically yield water at 100 to 200°C which can be converted into electricity.

HDR projects are currently being developed in several parts of the world, and some of these have the potential to yield substantial amounts of energy but as yet none is being operated on a sustainable, commercial basis. Two projects to exploit HDR prospects are currently being developed in the UK, which are both in the granite intrusions of Cornwall.

The estimated geothermal gradient for Scotland suggests a temperature of 150°C may be reached at a between approximately 4km and 5km depth, which is within the apparent practical lower depth limit for exploiting HDR resources. The lack of temperature data for crystalline rocks in deep (>2km) onshore boreholes means that caution should be exercised in applying the regional temperature gradient to potential HDR locations.

The best HDR prospects in Scotland are likely to exist in geological settings where heat produced by radioactive decay of elements like uranium (radiogenic heat) in the crust augments the background heat flow, producing localised high-temperature anomalies. There are numerous exposed granite intrusions in Scotland, and a small proportion of these produce significant

quantities of radiogenic heat. These ‘High Heat Production’ (HHP) granites occur mainly in the East Grampians region and locally to the north of Inverness. A previous investigation of the HDR potential of the East Grampians HHP granites reported disappointingly low heat flow values, but this work predated the research described above showing that heat flow values in Scotland probably underestimate the size of the heat resource beneath the climate-affected zone. The possibility remains, therefore, that some of the exposed HHP granite intrusions in Scotland have HDR potential.

Granite intrusions can be buried beneath a thick cover of younger sedimentary rocks. Where HHP granite intrusions have been buried in this way, some of the heat passing through and generated within the granite may become trapped beneath the sedimentary rocks, particularly if they are poor heat conductors. Over geological time, large reservoirs of trapped heat can potentially develop in this way. Buried granite intrusions are inferred to exist in Caithness, beneath the East Grampians region, and in south-east Scotland, but to date no buried intrusions of HHP granite have been proved in Scotland. Based on the distribution of HHP granite at outcrop, intrusions of HHP granite sitting beneath thick piles of sedimentary rock may exist beneath the Moray Firth and its onshore fringes.

The evidence base for assessing the potential for Hot Dry Rock prospects in Scotland is far from adequate. Most significantly, the understanding of the distribution in Scotland of exposed and buried intrusions containing HHP granite needs to be improved.

Policy Options and Key Actions

Development of the deep geothermal energy sector in Scotland will require a strong partnership between the Scottish Government, government agencies and stakeholders. It is anticipated that the Scottish Government have a significant role to play in initially establishing the industry sector.

Key actions have been identified and it is recommended that these are undertaken to encourage and facilitate development of the deep geothermal energy sector.

A progressive approach to developing Scotland’s geothermal resources is advocated to build confidence, reduce costs, and thereby encourage investment.

National Geothermal Energy Vision and Strategy for Scotland

It is recommended that development and implementation of a Vision Statement and a phased Strategy are required to steer and realise the development of the geothermal energy sector in Scotland. These will be directly linked to existing Scottish Government policies on renewable energy and heat (2020 Routemap, Outline Heat Vision, etc).

The Vision Statement will define the Scottish Government’s ambition for geothermal energy development in Scotland, and to set goals to be reached at certain defined points in the future.

Experience gained from development of progressively deeper schemes will increase market confidence, reduce costs, and thereby encourage investment.

It is anticipated that the Vision Statement will present a progressive approach to developing Scotland's geothermal resources with targets for:

- Short to medium term (say 0 to 10 years+) - developing the supply of heat from geothermal resources (e.g. abandoned mine workings) and allied technology and infrastructure.
- Medium term (say 5 to 10 years+) - potential development of deeper resources for heat and potentially generation of baseload electricity (e.g. Hot Sedimentary Aquifers).
- Medium to longer term (say 5 to 20 years+) - potential development of deeper Hot Dry Rock resources using Enhanced Geothermal Systems (EGS) for generation of baseload electricity.

Experience gained from development of progressively deeper schemes will increase market confidence, reduce costs, and thereby encourage private investment.

The Strategy is the routemap that will outline how the Vision for geothermal energy development in Scotland will be realised. The Strategy will have several strands, technical, administrative, regulatory and commercial.

Geothermal Demonstrator Projects

In order to increase confidence in the geothermal resources and technologies, it is recommended that a initial geothermal demonstration and evaluation project (or projects) is developed and installed as soon as feasibly possible. This would be a full scale working scheme, supplying heat to an identified demand. The demonstrator should be a heat-only project most likely utilising abandoned mine workings as the geothermal resource. Potential opportunities are known to exist in and around Scotland's two largest conurbation areas; Glasgow and Edinburgh.

Following the implementation of the National Geothermal Exploration Programme (see below), it is anticipated that demonstrator projects may be required for deeper resources (HSA and HDR). This is due to the high level of risk associated with such deep drilling. The opportunities for locating these initial projects can only be determined following the exploration programme.

National Geothermal Exploration Programme

Many of the barriers to development of the geothermal sector in Scotland centre around our current knowledge level of the resource. In particular, the geothermal gradients and heat flow is poorly understood and there is a poor understanding of potential Hot Sedimentary Aquifers (HSA) and High Heat Production (HHP) granites ('HDR') at depth. Both of these are primarily due to the lack of suitable deep onshore borehole data. To advance the development of deeper geothermal resources in Scotland, a National Geothermal Exploration Programme is recommended, comprising:

- Creation of a National Geothermal Database;
- Research programme for deeper prospects; and
- Physical exploration programme.

The linkages between this proposed programme to any other existing and planned investigation programmes is still to be established.

Resource Ownership & Licensing

The legal ownership of geothermal resources is not currently defined under existing legislation. The uncertainty of ownership of geothermal resources is a potential risk for individual projects, which along with risks associated with geological uncertainty, gives rise to increased cost and can make it difficult to obtain sufficient finance to develop deep geothermal projects. It is recommended that the legal ownership of geothermal energy resources should be established to allow a geothermal resource licensing system to be developed by amending existing primary legislation or introducing new primary legislation, potentially in the form a 'Geothermal Energy Act'.

It is recommended that the Scottish Government explores further with DECC how to establish legal ownership (and introduction of a licensing system) either as UK priority, or alternatively, how this can be undertaken unilaterally by the Scottish Government.

Due to the likely timescale in drafting new legislation, interim measures are required to encourage commercial investment in the short term and medium term. It may be appropriate to have a two stage approach, initially creating relatively simple interim exploration and development legislation, as an amendment to existing legislation, to be replaced at a later date with more comprehensive and stand-alone legislation, as the industry develops and matures.

In the intervening period it is recommended that geothermal development is controlled through the development management (planning) regime through the EIA process. Some changes to planning guidance would be required to enable this.

The enactment of geothermal resource licensing should be such so as not to inhibit the take-up of GSHP technology and it is recommended that resources shallower than 200m depth should be either exempted from future licensing or made subject to General Rules.

Environmental Regulation

Environmental legislation relating to assessment and consenting issues are based on various European Directives and associated UK and / or Scottish legislation or regulations and these are well established in Scotland. It is considered that the existing framework of legislation is complete and robust, should cover the likely types of deep geothermal projects likely to come forward in Scotland and significant changes to are unlikely to be required.

Consideration should be given to how deep geothermal energy is considered under the EIA Regulations 2011 and whether the full sub-surface extent of the geothermal developments should be considered regardless of the surface footprint of the development.

Geothermal projects are specially identified in Schedule 3 of the Water Environment (Controlled Activities) (Scotland) Regulations 2011 ('CAR'). It is recommended that SEPA should consider whether the application of the existing General Binding Rules is appropriate to future larger-scale geothermal developments which may be abstracting and re-injecting large volumes of water.

Heat is considered under CAR as a potential pollutant and it is recommended that SEPA should clarify what would constitute groundwater heating or cooling 'pollution' in relation to geothermal developments.

Planning Policy

It is important to create a supportive planning framework. Current planning applications can only be dealt with under existing planning policies and to deal with primary planning impacts in terms of policy context requires strategic level support.

A key challenge is including and promoting geothermal energy at national planning policy level as individual geothermal energy developments are likely be classified as 'Local Developments' under the Hierarchy Regulations, however, geothermal energy may become of national significance as an energy source in the future.

It is recommended that specifically including geothermal energy at national planning policy level in the revised SPP is considered. This could include a statement on a presumption in favour of geothermal developments. It is also recommended that geothermal energy is also specifically included in the current ongoing review of the NPF for NPF3. Policies on geothermal energy should be adopted by Planning Authorities in the next review of their Structure Plans, Strategic Development Plans and Local Plans;

The spatial distribution of deep geothermal resources should be provided to Planning Authorities so that it they can be combined with heat demand (identified from heat mapping) and so the two can be linked.

It is recommended that consideration should be given to policies that incentivise, encourage or compel the use of sustainable heat systems (for example district heating) and heat sources (for example geothermal heat).

Costs and Financing

There is a significant differential in technological, risk and costs uncertainty between relatively shallow heat-only developments and deeper primarily electricity-generating developments. It is anticipated that experience gained from the demonstrator project(s), and progressively deeper schemes will increase developer and investor confidence, reduce costs and thereby encourage development.

For heat-only developments, the proposed Renewable Heat Incentive (RHI) is welcome support for deep geothermal and could help to start unlocking the geothermal development potential. The proposed level of 5p/kWh for ‘deep’ geothermal has been broadly welcomed by developers.

It is considered that for an emerging technology, with the potential to provide baseload electricity generation, the level of support for deep geothermal should be increased to between 4 and 5 ROCs.

Even with this level of support through ROCs, there is likely to be a significant funding gap and additional support is likely to be required to attract and encourage deep geothermal developments for electricity generation. Given the prevailing economic situation and significant competing demands it may be difficult for the government to commit any funding to cover this gap. However, costs should reduce over time as confidence increases and technology advances, and the funding gap should reduce.

It is recommended that the Scottish Government investigates how it can act to unilaterally to support deep geothermal projects in Scotland, potentially setting up a deep geothermal fund to provide support. Any government funding would be subject to State Aid regulations.

Geothermal exploration risk insurance has been requested by some potential geothermal developers to encourage otherwise risky investment. The Scottish Government have advised that this would be potentially difficult due to competing priorities.

It is recommended that the Scottish Government should investigate whether other institutions could provide exploration risk insurance (for example the Green Investment Bank or the commercial insurance sector). The European Geothermal Risk Insurance Fund (EGRIF) proposed by the European Geothermal Energy Council (EGEC) may also provide an alternative.

Introduction

1 Introduction

1.1 Context

The Energy and Climate Change Directorate (ECCD) of the Scottish Government (the Client) have identified deep geothermal energy as a particularly important emerging renewable energy technology that could have the potential to play a significant role in Scotland's future energy provision.

Exploitation of deep geothermal heat energy could potentially deliver many benefits to Scotland, including:

- Reducing carbon emissions and helping Scotland build a sustainable low-carbon economy in order to meet the legislative requirements for emissions reductions;
- Increase the use of renewable heat to help exceed the targets set out in the 2020 Routemap for Renewable Energy in Scotland;
- Potentially help to exceed the targets for renewable electricity production;
- Become a viable alternative source of energy, improving local and national energy security and reducing reliance on external sources of energy;
- Help reduce fuel poverty through the use of district heating networks;
- Regenerate brownfield sites, including in former mining and industrial areas;
- Provide skilled employment opportunities, with cross-over with the oil and gas and manufacturing sectors; and
- Push Scotland towards the forefront in the technology required for exploiting deep geothermal resources, particularly in areas previously considered as marginal or even not viable.

To date, the extent and location of the potential deep geothermal resources has not been well defined. In addition, potential commercial investment in development of deep geothermal energy requires greater certainty on the current administrative framework, including clarification of legal ownership of resources legal ownership, resource licensing, supportive planning and permitting regimes, and financing.

1.2 Scope of this Report

The Scottish Government commissioned AECOM (in collaboration with the British Geological Survey) to carry out a study to identify the next steps that are necessary to take forward the commercialisation of deep geothermal energy in Scotland, comprising the following:

- **Stage One** – assessment of the areas most likely to hold deep geothermal resource based on existing geological data sets, and
- **Stage Two** – Identification of policy options and key actions that the Scottish Government can implement to encourage commercial exploitation of the available geothermal resource, including providing policy options, key actions, and who should be responsible for their implementation.

Stage two includes assessment of resource licensing (and the wider implications of any proposed licensing regime), environmental regulation and consenting, planning, and cost, benefits and financing.

The study has been carried out under the Scottish Government project number AEC/001/11.

This report has been undertaken by AECOM on behalf of the Scottish Government and does not necessarily represent the views of the latter.

1.3 The Content of this Report

1.3.1 Stage One

The British Geological Survey (BGS) undertook stage one in collaboration with AECOM. The BGS are uniquely placed in terms of geological knowledge and skills in order to identify the areas likely to contain the most significant geothermal resources.

The BGS's resulting report, 'Deep geothermal energy potential in Scotland' (BGS Commissioned Report CR/12/131, 26 April 2013) is summarised as a non-technical summary (NTS) in Section 2 and the full report is contained in Volume 2 of this report.

The first part of the BGS's report includes a background to geothermal energy, sets the geological context and summarises the geothermal data currently available for Scotland. The second part of the report reviews the available geothermal resources in three key geological scenarios; abandoned mine workings, hot sedimentary aquifers and hot dry rocks.

1.3.2 Stage Two

AECOM undertook stage two and this comprises:

- A review of legal ownership of deep geothermal resources based on advice to the Scottish Government from DECC;
- A review of potential resource licensing for Scotland;
- A review of the existing regulatory regime for deep geothermal developments;
- A review of the likely costs, financial risks, financing options and potential benefits; and

- Recommendations for policy options and key actions in the above areas.

Following initial research, a stakeholder workshop was undertaken at the BGS's offices in Edinburgh on 31 October 2012 to present the findings of the initial research and to gather the views of a wide range of stakeholders across the geothermal sector. The main outputs from the workshop are summarised in Appendix C, including a list of participating organisations. These outputs were used to inform and guide the second part of the study which is presented in this report.

Non-Technical Summary: Potential Geothermal Resources in Scotland

2 Non-Technical Summary: Potential Geothermal Resources in Scotland

2.1 Introduction

2.1.1 Geothermal Energy Resources

Geothermal energy is simply the natural heat that exists within our planet. In some parts of the world the existence of a geothermal energy resource is made obvious by the presence of hot springs, and such resources have been exploited in various ways for millennia. More usually, there is no direct evidence at Earth's surface of the vast reservoir of stored heat below, and geothermal energy has remained largely ignored and untapped in most parts of the world. Now, its potential as a renewable source of energy is being recognised increasingly, and technologies and concepts for exploiting it are developing rapidly along two lines: low temperature resources, which exploit warm water in the shallow subsurface to provide heat either directly (as warm water) or indirectly (via heat exchange systems); and high temperature resources, which yield hot water, usually from deeper levels, that can be used to generate electricity.

The potential for harnessing electricity from geothermal energy has long been recognised; the potentially substantial reserves, minimal environmental impact, and capacity to contribute continuously to base load electricity supply make it an extremely attractive prospect. The ongoing drive to develop renewable sources of energy, coupled with anticipated technological developments that will in future reduce the depth at which heat reservoirs are considered economically viable, means there is now a pressing need to know more about the deep geothermal energy potential in Scotland.

2.1.2 Scope

The Stage One deliverable for this study is "Identifying and assessing geothermal energy potential" (in Scotland). The British Geological Survey (BGS) have, on behalf of AECOM undertaken a qualitative assessment of deep geothermal energy potential in onshore Scotland comprising an assessment of areas in Scotland most likely to hold deep geothermal resources based on existing geological and geothermal data sets.

The BGS's full report is included as Volume 2 of this report. This section of the report provides a non-technical summary (NTS) of the main findings of the BGS's assessment.

The main report is divided into two parts. Part 1 sets out the background to geothermal energy, describes the geological context, and presents an analysis of the size and accessibility of the heat resource in Scotland based on existing geothermal data. Part 2 sets out the potential for exploiting deep geothermal energy in three settings in inshore areas of Scotland (abandoned mine workings, Hot Sedimentary Aquifers, and Hot Dry Rocks). Recommendations relating to further work for developing each of these settings have also been made.

2.1.3 The Heat Resource in Scotland

Scotland sits on a geologically stable part of Earth's crust and has none of the obvious features - such as hot springs or volcanic activity - that would indicate the presence of a substantial heat resource in accessible parts of the subsurface.

Heat flow is the standard measure of the amount of heat travelling through Earth's crust, and heat flow measurements (usually made in shallow boreholes) are the standard means of gauging the size of the heat resource at depth. The average heat flow reported for Scotland is lower than the mean value for all continents, and significantly lower than values historically associated with exploitable resources of deep geothermal energy.

In order to calculate a heat flow value, the geothermal gradient (the rate at which temperature increases with depth in the Earth's crust) must be measured in a borehole. Within the last decade, research has shown that warming of the ground surface since the last period of widespread glaciation (the 'Ice Age') has perturbed the geothermal gradient within the top 2km of the crust, with the result that measured geothermal gradient values (and therefore heat flow values) are reduced. Scotland was strongly affected by the 'Ice Age' glaciations, so existing heat flow measurements in Scotland probably significantly underestimate the true size of the heat resource that exists beneath the climate-affected zone. Published data suggest that recent changes in the climate may have suppressed near-surface heat flow by as much as 60% in some parts of northern Europe and North America. Preliminary, unpublished work by the BGS indicates that heat flow values in the East Grampians region of Scotland may be suppressed by up to 29%. These findings suggest that heat flow below the climate-affected zone in Scotland (which may extend to a depth of around km) is significantly greater than was previously assumed.

Temperature data measured in boreholes provide the best currently available alternative means of examining the size and distribution of the heat resource beneath Scotland. Borehole temperature data from 133 boreholes ranging up to 5km deep and representing both onshore and offshore parts of Scotland display a well-defined trend when plotted as temperature versus depth. The geographical extent of the data and the consistency of the trend throughout its depth range suggest the trend may represent a regional temperature gradient for Scotland. The gradient is slightly curved and increases with depth, from 30.5°C/km in the shallowest third to 46.7°C/km in the deepest third. These values, which equate to temperatures of 100°C and 150°C at depths of approximately 3.0 and 4.0km, respectively, suggest there is a significantly larger heat resource at accessible depths beneath Scotland than has been suspected previously. However, the data defining the trend come mainly from offshore boreholes in sedimentary rocks, and caution should be exercised in extrapolating the same gradient to deep levels onshore, particularly in crystalline rocks. More research is needed to test this result; nevertheless, the

borehole temperature trend suggests the temperature gradient in the crust beneath Scotland may be significantly higher and more consistent regionally than has been recognised hitherto.

The regional geothermal regime beneath Scotland is still relatively poorly understood. A better understanding of the regional distribution of heat, both laterally and vertically, in shallow parts of the crust is needed before decisions are made regarding the location and design of more detailed, site-specific studies.

2.2 Geological Settings for Exploiting Geothermal Energy

The geothermal heat resource beneath Scotland can be considered in terms of three main settings: abandoned mine workings (low temperature), hot sedimentary aquifers (low and possibly relatively high temperature), and hot dry rocks / petrothermal sources (relatively high temperature).

2.3 Abandoned Mine Workings

Scotland's Midland Valley is underlain in many parts by a network of abandoned mines. These once employed thousands of miners to extract coal, ironstone and other minerals and are the basis and location of many towns and villages. They provided the energy and raw materials that powered industry in the 19th and 20th centuries, and the fuel to heat domestic properties. With industrial change and economic decline the mines closed so that there are no underground mines still in operation. The now flooded mines could play an important role in future in energy supply, providing access to thermal reservoirs which could help to heat homes and other buildings, and contribute to the energy mix of a low carbon Scottish economy based substantially on renewable energy.

Two installations of GSHPs currently tap mine water in Scotland: Shettleston in east Glasgow and Lumphinnans in Fife. Both are small schemes, each serving less than 20 dwellings, and have been operating since 1999–2000.

Most mine workings were collapsed in a controlled way soon after the resource had been extracted, but these rubbly collapsed layers can store and transmit significant volumes of groundwater. Larger voids remain underground in the form of old mine shafts and roadways, as many of these were constructed to a high standard and are still propped open.

During their operation, very large volumes of water had to be pumped from the mines. This water, held naturally in the rocks as groundwater, entered the mine workings, but with pumping, the level at which groundwater occurred around the mines was greatly lowered so they could function in relatively dry conditions. When mining ceased, pumping ceased also in most instances allowing the natural levels of groundwater to re-establish. As a result, most of the abandoned mine workings become flooded, and remain so today. The abandoned mine

workings now contain significant volumes of water. In addition and arguably more importantly, they provide potential access to the very much larger volumes of water held in the rocks within which the mines occur. The volumes of water in the surrounding rocks are of the order of 100 times greater than the volumes of water in the mine workings.

Therefore, the abandoned and flooded mine workings and their surrounding rocks have very large subsurface volumes, which in turn contain very large volumes of water. It is the water which and provides significant potential for heat exchange. This, and the associated potential high abstraction rates as a result of the mining-enhanced permeability, makes them potentially suited to large, open-loop ground source heat pump (GSHP) systems. These open-loop systems would not be open to the atmosphere as the chemistry of the mine waters, and particularly their potentially high iron content, could result in iron precipitation if exposed to atmospheric oxygen.

Mine workings typically worked several relatively flat lying seams of coal (etc) in a vertical succession. These often spanned a significant depth range (up to several hundred metres). This could enable water to be abstracted from one depth interval for example towards the bottom of the mine, and returned to the ground at a different depth for example at a significantly shallower depth and after heat has been extracted from the water. This vertical separation can be advantageous in increasing the time before the returned water, at lower temperature and shallower depth, starts to arrive at the point of abstraction where water warms at greater depth. This can in turn improve the efficiency of a scheme. Mines can extend to relatively deep levels, so in some cases they can provide easy access (e.g. via remnant shafts) to higher temperature water. For example, a borehole at the Solsgirth Colliery in Clackmannanshire recorded a temperature of 21.5 C at a depth of 387 metres. Deep boreholes (800 metres) at Heerlen in the Netherlands intercepted water of about 35 C.

In 2004, the Scottish National Mine Water Potential Study assessed the largest 62 coal mines in Scotland; the number of men that worked down the mine was used as a proxy for the volume of mine water that might be available. The study considered the potential for mine water heating at Shawfair, near Edinburgh, as part of a consideration of the wider potential across the Midland Valley of Scotland. It was calculated that mine waters could contribute up to 1,708 gigawatt hours (GWh) per annum of heat, if grants were provided. This equates to about 3% of their estimate of Scotland's total annual heat demand in 2004.

This assessment of the geothermal potential of mine water in Scotland draws on recent work by the BGS, including three-dimensional (3D) modelling of the ground, and utilises other available data to provide an estimate of potential borehole yields and the extent of the likely resource across the Scottish coalfields. The appraisal is based on the best estimates of geological and hydrogeological properties of the mined areas, providing a different viewpoint from earlier studies. Ironstone and oil-shale mines within the Midland Valley also have the potential for use in

mine water heat recovery. From the BGS 3D modelling, borehole data, and Coal Authority extent-of-mining data, it is estimated the volume of the mine-worked area (i.e. from the base of the mine workings to land surface) to be 600km^3. It is this approximate volume of rock, and the mine workings themselves, that groundwater can be abstracted (pumped), and from which heat can be extracted.

The two key parameters which influence the potential for getting heat from mine waters are the flow rate at which water can be abstracted from the subsurface without significantly depleting the resource, and the temperature of that water.

It is very difficult to predict the likely flow rate (borehole yield) that a particular borehole might obtain due to the great variability in mining-enhanced aquifers, but analysis of available data has enabled us to establish a typical range of yield. In general, it is thought reasonable to expect a yield of about 10 litres per second (l/s) in mining-enhanced aquifers, from an individual borehole penetrating a reasonable water-saturated thickness of strata (minimum of 50 metres). For the purposes of the calculations of potential heat abstraction, a range of 5 to 25l/s per borehole seems reasonable. Assuming that this yield could be achieved in boreholes spaced at 4 boreholes per km^2, it is assumed that the groundwater could be exploited at a rate of 20 to 100l/s/km^2. This rate of pumping would be far in excess of the natural recharge rate and would be unsustainable without re-injection of the water to the aquifer (i.e. the shallow mine workings) after heat has been extracted.

The temperature of mine waters generally increases with depth according to the geothermal gradient. It is not simple, however, to predict the temperature of water pumped from a borehole, as water of different temperature may be entering the borehole at different depths. A compilation of mine water temperatures for boreholes in the Midland Valley shows a fairly narrow spread of temperatures from 12 to 21°C, with a mean (and median) of 17°C. However, this may not accurately reflect the higher temperatures that may occur in some of the deepest mine workings in Scotland.

It is estimated that some 2.5 megawatts per kilometre square (MW/km^2) could be obtained on average using open-loop ground source heat systems in the mined areas of Scotland. Multiplying this value by the number of square kilometres in the mined area (4.8 x 10^3 km^2) gives a very approximate estimate of the accessible heat of 12,000MW (12GW). This is considered to be an approximate estimate of the maximum potentially accessible resource, i.e. how much heat energy could theoretically be extracted from all the mined areas of the Midland Valley, bearing in mind the geological constraints on how much water can in practice be abstracted.

On this basis, mine waters could theoretically provide the equivalent of approximately one third of Scotland's heat demand. However, the actual contribution is likely to be significantly less for three main reasons:

- heat cannot be transported efficiently over large distances, so would only be used above or close to suitable mine workings (although many towns and villages in Scotland's Midland Valley lie directly above mine workings, reflecting their historic roots);
- a proportion of mine workings will not be suited to heat extraction; and
- the low-grade heat delivered by GSHP is most effectively used in well insulated new-build properties and existing building stock would likely require extensive upgrading to benefit from mine water heat.

If Scotland accessed as much of the heat in the mine waters as possible (approximately 2.5 MW/km^2), it may last for approximately 37 years. This ignores the reality that additional heat would flow into the mined areas from Earth's interior and solar input. Practicalities also mean that it is unlikely to be possible to access the heat at the maximum possible rate, in which case the supply that is tapped will last longer than the above estimate. Nor does the estimate take into account potential recharge from using the minewaters as a source of cooling during the summer.

Specific areas within the Midland Valley have not been selected as having more favourable prospects for mine water heat recovery as economic and technical factors are likely to play a greater role in site selection.

Mine water in abandoned workings in Scotland's Midland Valley presents a potentially important geothermal resource which might be used (by heat exchange) for space and domestic hot water heating, and related uses. However, there are many assumptions and generalisations in this assessment and further work is recommended.

Any abstraction of minewater would balanced by re-injection following extraction of heat, the groundwater level is therefore unlikely to change significantly and the risk of inducing subsidence is considered to be low.

2.4 Hot Sedimentary Aquifers (Hydrothermal Resources)

Aquifers are bodies of permeable rock that can conduct significant quantities of groundwater. The largest and most conductive aquifers generally occur in sedimentary strata, and any of these that are hot enough and have sufficient productivity to constitute a potential geothermal resource can be termed a Hot Sedimentary Aquifer (HSA). HSA resources are likely to exist, in general, down to depths of around 4km, and most will yield water in the temperature range 20 to 80ºC. The hot water can be used for heating, either directly or indirectly (by heat exchange). The first, and so far only, successful HSA system developed in the UK is in Southampton. Opened in

1986, the system exploits warm water (<80°C) at a depth of nearly 2km in sedimentary strata. A combined heat and power (CHP) system delivers sustainable supplies of heat (district heating), chilled water and electricity.

Most of Scotland (including much of the Highlands and Southern Uplands areas) is underlain by relatively impermeable crystalline (non-sedimentary) rocks, which have no HSA potential. The Midland Valley is the largest onshore part of Scotland to be underlain by sedimentary strata, and the best HSA prospects are likely to be here. However, the Midland Valley is geologically complex, and it can be difficult to make geological correlations between boreholes and to extrapolate surface observations below the ground surface. Interpretation in some areas is complicated further by the influence on groundwater flow of abandoned and active coal mines. The aquifers are typically of variable lithology, intruded by relatively impermeable igneous rocks, fractured, faulted and generally complex.

The best HSA prospects in Scotland are probably in Devonian sedimentary strata (roughly 420 to 360 million years old) underlying the northern part of the Midland Valley and the southern onshore margin of the Moray Firth Basin, and in Permo-Triassic strata (roughly 300 to 200 million years old) filling small geological basins in parts of south-west Scotland. It is emphasised, however, that current understanding of the distribution and properties of aquifers in Scotland comes very largely from surface and near-surface observations, and relatively little is known about aquifer distributions and properties at depth. The ability of water to move through rocks can change significantly with depth, and testing in deep boreholes will be required to gauge the suitability at depth of any setting with HSA potential.

Relatively high temperatures at the bottom of some coastal boreholes suggest that hot water from offshore sedimentary aquifers may have migrated locally to shallower levels in onshore margins of the aquifers. It may prove possible in some places to access HSA prospects in offshore (near-shore) sedimentary basins by drilling inclined boreholes from onshore coastal locations. It is noted however that such schemes may not be economically viable due to the cost of directional drilling.

2.5 Hot Dry Rocks (petrothermal sources)

In Hot Dry Rock (HDR) resources, heat is extracted from ‘dry’ crystalline rocks by fracturing them, injecting cool water into the hot fractured rock, and extracting the resulting hot water. This requires the development of an Enhanced (or Engineered) Geothermal System (EGS). The EGS concept typically involves developing a ‘loop’ in the hot rock consisting of boreholes at either end of a network of connected and open induced fractures (enhancement of permeability), through which cold water is introduced and hot water is removed. HDR resources typically yield hotter

water (100 to 200°C) than HSA resources, and the thermal energy stored therein is converted into electricity at the surface.

HDR projects are currently being developed in several parts of the world, including Australia, France, and the USA. Some of these have the potential to yield substantial amounts of energy but as yet none is being operated on a sustainable, commercial basis. Two projects to exploit HDR prospects are currently being developed in the UK, both in the granite intrusions of Cornwall: the United Downs Project and the Eden Deep Geothermal Energy Project.

HDR resources typically will be deeper and hotter than Hot Sedimentary Aquifer (HSA) resources. Consequently, they have the potential to produce electrical power, but they will probably present a greater technical challenge than HSA resources. In recent years the development of binary cycle power plants, in which electricity can be generated using water that is cooler than 100°C, has greatly improved the potential for recovering geothermal energy from HDR prospects that previously would have been considered marginal or not viable.

The ‘regional geothermal gradient’ for Scotland (see 2.1.3 The heat resource in Scotland) suggests a temperature of 150°C would be reached at a depth of approximately 4,000 metres, which is within the widely quoted practical lower depth limit for exploiting HDR resources (5,000 metres). If the more conservative geothermal gradient suggested by borehole temperature data from onshore boreholes is used (30.5°C/km) then 150°C should be encountered at approximately 4,900 metres, still within the ‘accessible zone’. However, the lack of temperature data for crystalline rocks in deep (>2km) onshore boreholes means that caution should be exercised in applying the regional temperature gradient to potential HDR settings.

The best HDR prospects in Scotland are likely to exist in geological settings where heat produced by radioactive decay of elements like uranium (radiogenic heat) in the crust augments the background heat flow, producing localised thermal anomalies. There are numerous exposed granite intrusions in Scotland, and a small proportion of these produce significant quantities of radiogenic heat. These ‘High Heat Production’ (HHP) granites occur mainly in the East Grampians region, and two crop out to the north of Inverness. A previous investigation of the HDR potential of the East Grampians HHP granites reported disappointingly low heat flow values, but this work predated the research described above showing that heat flow values in Scotland probably underestimate the size of the heat resource beneath the climate-affected zone. The possibility remains, therefore, that some of the exposed HHP granite intrusions in Scotland have HDR potential.

Granite intrusions can be buried beneath a thick cover of younger sedimentary rocks. Where HHP granite intrusions have been buried in this way, some of the heat passing through and generated within the granite may become trapped beneath the sedimentary rocks, particularly if

they are poor heat conductors. Over geological time, large reservoirs of trapped heat can potentially develop in this way. Based mainly on geophysical evidence, buried granite intrusions are inferred to exist in Caithness, beneath the East Grampians region, and in south-east Scotland, but to date no buried intrusions of HHP granite have been proved in Scotland. Based on the distribution of HHP granite at outcrop, intrusions of HHP granite sitting beneath thick piles of sedimentary rock may exist beneath the Moray Firth and its onshore fringes.

The evidence base for assessing the potential for Hot Dry Rock prospects in Scotland is far from adequate. Most significantly, the understanding of the distribution in Scotland of exposed and buried intrusions containing HHP granite needs to be improved.

2.6 Recommendations for Further Work

The following recommendations are made for further work:

General

- Model the effect on the geothermal gradient of post-glacial warming.
- Improve the heat flow dataset for Scotland.
- Extend the borehole temperature dataset (bottom-hole temperature versus depth) to include all available data for Scotland.

Abandoned Mine Workings

- One or more site-specific studies should be conducted utilising existing information (including Coal Authority and the BGS's data), developing a detailed 3D model of the mine workings, gathering new information on borehole yields and permeability, and assessing the technical feasibility of installing an open loop GSHP system perhaps in combination with other forms of energy. The Glasgow area would be an obvious target given the availability of the BGS's 3D geological models and other previous studies as well as the expected scale of the ongoing developments and urban regeneration.
- The GSHP industry should be encouraged to deposit key data on installed schemes in a national archive, similar to that for borehole data held by the BGS to facilitate further modelling and potential exploitation of available thermal resources.

Hot Sedimentary Aquifers

- More detailed investigation of parts of the Midland Valley to identify specific targets with HSA potential.
- Further investigation of possible thermal anomalies in some onshore margins of large offshore basins such as the Moray and Solway firths and the Firth of Clyde.

- Testing in deep boreholes to gauge the actual permeability and overall productivity at depth in settings with HSA potential.

Hot Dry Rocks

- Compile heat production data for all the granite intrusions of Scotland to identify all intrusions that have HHP character at outcrop.
- Conduct research to identify whether some of the exposed intrusions that do not have HHP character would have had HHP character in now-eroded portions, or may have HHP character in still-buried portions.
- In offshore areas, use seismic survey data and information from wells to identify buried intrusions and intrusions exposed on the sea floor.
- In onshore areas, re-interpret existing regional geophysical data and 3D geological models using modern methodologies and up-to-date knowledge of the surface and subsurface geology to identify possible buried granite intrusions (and other potential HDR settings).
- Characterise the fracture network in exposed HHP intrusions.
- Conduct a programme of deep drilling to provide measured and observed, factual data from within the deep geothermal regime; to penetrate beyond the influence of surface- and near-surface effects on the geothermal gradient, a deep geothermal borehole would probably need to extend to a depth of at least 3km, and ideally to 5km.

The Ownership of Geothermal Resources in Scotland

3 The Ownership of Geothermal Resources in Scotland

3.1 Introduction

The lack of clarity on the legal ownership of geothermal resources, and therefore the lack of an associated resource licensing system, is seen as a significant barrier to investment in commercial exploration and development of geothermal resources in Scotland (and also the other parts of the UK). This uncertainty over the ownership potentially discourages private investment in deep geothermal projects. This section therefore seeks to clarify the legal ownership of geothermal resources in Scotland.

Potential options for a suitable licensing framework are discussed in Section 4 - Potential Geothermal Resource Licensing Options, and some duplication is inevitable here.

3.2 Legal and Policy Context

Under the terms of the Scotland Act 1998 that created the devolved Scottish Parliament, energy regulation in Scotland is a matter that has been specifically reserved to the UK Parliament at Westminster.

Under the Section 30 of Scotland Act 1998 there is the potential for reserved powers to be transferred from the UK Parliament to the Scottish Parliament.

Promotion of renewable heat is devolved. The Scottish Government also has the ability to influence actual energy generation in Scotland through planning, which is a devolved matter, by both setting planning policy and by approving (or refusing) individual new projects.

3.3 Scottish Renewable Energy Policy

The following documents set out the primary policies of the Scottish Government for renewable energy generation and heat:

- 2020 Routemap for Renewable Energy in Scotland (2011, with a subsequent update in 2012), see http://www.scotland.gov.uk/Publications/2011/08/04110353/0 and http://www.scotland.gov.uk/Topics/Business-Industry/Energy/UpdateRenewableRoutemap.
- Renewable Heat Action Plan for Scotland: a plan for the promotion of the use of heat from renewable sources (2009, with subsequent updates in 2010 and 2011), see http://www.scotland.gov.uk/Publications/2009/11/04154534/0.
- Outline Heat Vision (2013), see http://www.scotland.gov.uk/Topics/Business-Industry/Energy/Energy-sources/19185/Heat/DraftHeatDeployment.

- Scotland's Heat Map (draft, 2013), see http://www.scotland.gov.uk/Topics/Business-Industry/Energy/Energy-sources/19185/Heat/HeatMap.

3.3.1 2020 Routemap for Renewable Energy in Scotland

The Routemap for Renewable Energy in Scotland (2011) updated and extended the Scottish Renewables Action Plan 2009. It sets out the target to meet an equivalent of 100% demand for electricity from renewable energy by 2020, as well as a target of 11% heat from renewable sources. It was updated in 2012 to reflect developments across the renewables sector, progress made towards the 2020 targets, and included a new interim target to meet the equivalent of 50% of Scotland's electricity demand from renewable sources by 2015.

3.3.2 Renewable Heat Action Plan

The Renewable Heat Action Plan originally sought to implement the Renewable Heat Strategy (which was developed under the Forum for Renewable Energy Development in Scotland's, FREDS), in advance of the main market mechanism, the UK wide Renewable Heat Incentive (RHI) being introduced.

3.3.3 Outline Heat Vision

The document sets out a vision for a holistic approach across renewable and non-renewable heat supply, for domestic and industrial use, and also for developing longer term targets (to 2050). The vision sets out how renewable heat should be taken forward within the context of a holistic overall heat strategy, contributing to a low carbon and energy efficient future, including to reduce total final energy demand in Scotland by 12% by 2020, covering all fuels and sectors.

3.3.4 Scotland's Heat Map

Following an initial pilot study in the Highland Council region, heat mapping is currently being rolled-out across local authority areas in Scotland. The purpose of heat mapping to understand where heat need is (demand) and opportunities to generate and provide heat (supply). The programme is working with local authorities to support the development of local GIS (Geographic Information System) based heat maps. The local system means local data and priorities, such as fuel poverty, planning, economic opportunity or public sector estate, can be considered in the same map.

3.4 Scottish Government Consultation with DECC on Legal Ownership & Licensing

Following approach by potential developers and promoters of deep geothermal energy projects, the Scottish Government sought advice on the legal ownership of geothermal resources from the

DECC. The initial enquiry was made in June 2010, with subsequent enquiries submitted in December 2010 and March 2011. In addition, as part of this study, DECC responded to further enquiries by the Scottish Government on behalf of AECOM in December 2012.

The Department of Energy and Climate Change (DECC) is the UK Government department responsible for energy and climate change. DECC is responsible for certain aspects of energy policy on a UK-wide basis, including electricity, oil and gas, coal, nuclear energy and energy efficiency as these are reserved matters, i.e. they are not devolved to the Scottish Parliament.

DECC have stated that from a renewable energy policy point of view they welcome the use of geothermal heat. The following points summarise DECC's position in relation to the legal ownership and licensing of geothermal resources in Scotland.

3.4.1 Legal Ownership

DECC consider that while the Crown owns the right to oil and gas, and (some other) mineral deposits, the law is completely silent on the ownership of geothermal heat. DECC have, in the past, considered legislating to license the extraction (of geothermal heat energy), but this has not been taken forward as a priority. DECC understands that potential developers would welcome licensing.

DECC consider that what actually constitutes geothermal energy is not currently defined. In different countries, geothermal energy has been defined as a mineral, a water resource or as unique source of energy. For the purposes of establishing ownership and licensing, geothermal energy would need to be defined.

DECC considered that the heat which is the essence of geothermal energy is not itself capable of ownership. However, since the heat can only be transferred from the subterranean strata to the surface by the medium of some substance e.g. groundwater, it appears that any substance suitable to this purpose will be capable of ownership.

3.4.2 Right to License the Resource

Initial advice from DECC confirmed that Scottish Ministers would have the right to license geothermal heat extraction since heat (renewable heat policy) is a devolved matter. DECC did not consider that these devolved powers would be affected if the extracted heat is then converted into electricity.

DECC's later advice in December 2012 however stated that until the question of ownership is resolved, that they cannot take a view on whether or not licensing would be devolved.

3.4.3 Consideration of Licensing

DECC acknowledged the difficulties in establishing legal ownership and developing a licensing system.

DECC have previously considered amending oil and gas legislation to assert Crown rights on deep geothermal heat, but acknowledge that this would appear to overlook the question of devolved powers.

DECC have also reportedly considered how geothermal development could be controlled under Planning law as it is a devolved matter but did not specify the outcome of this consideration. With the exception of marine fish farming, current planning regulation by the Scottish Government relates to on-shore development only and a separate system would therefore for be required for licensing any geothermal developments offshore.

DECC stated that, with regard to considering geothermal energy as an inherent property of groundwater (the medium by which geothermal energy is usually extracted), then amendments that may be required to relevant groundwater regulations would need to be considered in consultation with the relevant authorities (presumably including SEPA). Considering geothermal energy as a property of groundwater would potentially avoid defining legal ownership and subsequent legislation and would treat geothermal energy as a minor aspect of water legislation, requiring subsidiary legislation as necessary. DECC expressed concern that this would result in decentralisation of control of geothermal energy extraction, creating uncertainties and inconsistencies for other (geothermal) developments.

DECC considered that there are a number of issues to address in relation to any licensing regime and the acquisition of ancillary rights for exploitation.

The rights of third-party landowners also need to be considered as geothermal energy extraction can extend underground beyond land ownership boundaries.

DECC considered that since the development of ‘hot water’ (hydrothermal) geothermal resources is technically different from the development of ‘hot rock’ (petrothermal) sources, it may be necessary to consider separate regimes for these two distinct types of resource.

3.4.4 Process to Legislate

DECC considered that if seeking to put into place a separate licensing regime for the installation and/or operation of deep geothermal heat equipment then it is likely to require Primary legislation.

DECC also considered that, if a licensing regime were to go further, for example to have accreditation scheme to set out who can or cannot install deep geothermal heat equipment (for

example approved or licensed installers) then consideration would be required as to whether this infringes on both European law and reserved or devolved issues.

DECC advised that the selection of a licensing body is a matter of choice when developing legislation and Scottish Government would need to consider how a proposed regime would differ from the planning regime.

3.5 Consideration of Legal Ownership Issues of the Geothermal Resources in Scotland

Clarification of the legal ownership of geothermal resources is required prior to consideration of appropriate existing or new licensing regimes. The following sections describe the ownership of the ground and natural resources within the ground.

3.5.1 The Status Quo

Existing schemes in the Scotland, and in the wider UK, although they have been properly controlled through relevant planning, consenting and regulatory regimes, agreements and landowner permissions, they have not been subject to resource licensing as no such licensing system exists. This includes the UK's only operating truly deep geothermal scheme in Southampton, which extends to circa 1.8km depth.

The majority of existing schemes in Scotland are ground source heat pump (GSHP) schemes, generally installed to shallow depths. At least one scheme known to the authors, extends to a depth of 200m with a total of sixty-six boreholes to supply heat to a large building in Aberdeen.

The only geothermal schemes in Scotland known to the authors are the mine water schemes at Shettleston in Glasgow (100m depth, single borehole) serving 16 new-build dwellings and a similar scheme at Lumphinnans in Fife (172m depth, single borehole).

To date, due to the scarcity of both GSHP schemes and geothermal schemes, there have been no known issues with interference between adjacent geothermal schemes in Scotland.

In London there is a planning requirement for buildings to have 10% of energy from renewable energy sources. Anecdotal evidence has been reported of interference between adjacent GSHP cooling systems in the aquifer under central London due to their prevalence and the fact that their installation is not controlled by licensing. It is anticipated that with a rise in the uptake of renewable energy, similar situations could potentially arise in Scotland's larger cities but this is likely to relate mainly to shallower schemes.

3.5.2 How Deep is 'Deep' Geothermal?

There is currently no single agreed or accepted definition of what depth constitutes 'deep' geothermal energy either nationally or internationally. This is partially due to the wide variations

globally in the availability and depth of geothermal resources. This report is focussed on 'deep' geothermal resources, defined in the brief as resources at greater than 100m depth.

It is apparent that there are also various other definitions in use for defining what constitutes 'deep' geothermal resources. There is a gradation from the near surface, affected by solar radiation, to greater depths that are influenced only by heat from the earth's core ('true' geothermal energy) and no clear boundary.

This study has only directly considered true geothermal energy. Shallow and generally small-scale ground source heat pump (GSHP) developments, which exploit the temperature variation between the shallow sub-surface (which remains relatively constant) and the atmosphere, and extend only to relatively shallow depths, have not been considered.

In developing a licensing regime, the depth of the resources that it would apply to needs to be considered.

3.5.3 Land Ownership

Under Scottish law, a landowner theoretically owns from the sky to the centre of the earth, described as "a coelo usque ad centrum", i.e. the extent to which a plot of land extends upwards and downwards. This concept is now qualified by planning and other legislation, including the rights to overfly the property in aircraft and the Crown's right to Minerals (see below).

DECC advised the Scottish Government that if a proposed licensing regime is to interfere with the property of third parties, then careful consideration would be required, including what sort of rights may be given, what sort of compensation may be due (if any) and what responsibilities may arise from these rights, e.g. potential subsidence.

3.5.4 Mineral Definition & Ownership

In Scotland (and in the UK as a whole) 'minerals' are defined in The Town and Country Planning (Scotland) Act 1997 and The Town and Country Planning (Minerals) (Scotland) Regulations 1998 as including "all substances of a kind ordinarily worked for removal by underground or surface working" but excludes mineral workings for agricultural purposes and working of peat for domestic use.

In addition, a mineral-working deposit means "any deposit of material remaining after minerals have been extracted from land or otherwise deriving from the carrying out of operations for the winning and working of minerals in, on or under land" and the winning and working of minerals includes "the extraction of minerals from a mineral working deposit".

The British Geological Survey Minerals UK website provides a useful summary of the ownership of minerals in the United Kingdom and the following summary is based on this, see:

http://www.bgs.ac.uk/mineralsuk/planning/legislation/mineralOwnership.html

In the UK (including Scotland) the “Crown” (the state) owns the mineral rights to oil, gas, coal, gold and silver. Generally other minerals are in private ownership, and information on both mineral rights, where available, and land surface ownership is held by the Land Registry.

Crown land is managed on behalf of the government by the Crown Estate and there is still a presumption that land is owned by the Crown unless there is evidence to prove otherwise. The Crown Estate is now managed by a Board who have a duty to maintain and enhance the Estate.

3.5.5 Oil and Gas

Ownership of oil and gas within the land area of Great Britain (including territorial waters, within 12 miles of the shore) was vested in the Crown by the Petroleum (Production) Act 1934. Subsequently the Continental Shelf Act 1964 applied the same provisions to the UK Continental Shelf (UKCS) outside territorial waters to those areas of the seabed and beneath the seabed, beyond territorial waters, over which the UK exercises sovereign rights of exploration and exploitation of mineral resources.

In the UK, DECC licenses (on behalf of the Crown) the exploration and production of oil and gas resources for both on shore (‘landward’) and off shore (‘seaward’) resources through Petroleum Licences and these grant exclusive rights within the licensed area for certain defined periods (for a fuller description of Petroleum Licences see Section 4 - Potential Geothermal Resource Licensing Options).

Shale gas and coal bed methane are also covered by oil and gas exploration and production licences.

3.5.6 Coal

The ownership of almost all coal in Great Britain now resides with the Coal Authority, a non–departmental public body (and part of DECC), who grant licenses for coal exploration and extraction (on behalf of the Crown).

The Coal Authority has responsibility for all the interests in respect of unworked coal and coal mines, and also the liabilities associated with past coal mining and unworked coal.

The Coal Authority grant exploration and extraction licences for coal. Licences are also required from the Coal Authority for any other disturbance to unworked or worked coal. This would include geothermal developments, and coal bed methane and coal mine gas extraction.

The Coal Authority has also developed a separate system of “Heat Access Agreements” to control abstraction of geothermal heat from former coal mine workings and / or coal reserves (see Section 4: Potential Geothermal Resource Licensing Options).

3.5.7 Unconventional Gas

‘Unconventional’ gas includes underground coal gasification (UCG), coal bed methane (CBM) and shale gas.

SEPA’s “Regulatory guidance: Coal bed methane and shale gas” (2012) sets out the regulatory regime for unconventional gas. Resource licensing for CBM and shale gas is governed by the DECC’s existing Petroleum Licensing regime (PEDL).

For UCG, under the Coal Industry Act 1994, the Coal Authority issues “Underground Coal Gasification Operating Licences” and, where necessary, an associated Lease.

For any activity that intersects, disturbs or enters coal seams, prior written authorisation from the Coal Authority is also required. The Coal Authority also grant “Coal Methane Access Agreements” to control access to coal bed methane from coal reserves.

In addition, the local Planning Authority is responsible for granting planning permission (under the Town and Country Planning (Scotland) Act 1997) for surface works associated with borehole construction, fracturing operations and wellhead development. SEPA is a statutory consultee to planning applications.

The Borehole Sites and Operations Regulations 1995 place a duty on operators of petroleum borehole sites to ensure that no operations which would make a significant alteration to the well, or involve a risk of accidental release of fluids from the well, are carried out unless they have notified the Health and Safety Executive (HSE) at least 21 days in advance.

3.5.8 Hydraulic Fracturing

The technique of fracturing (commonly known as “fracking”), is often used to increase production of unconventional gas.

Hydraulic fracturing may be required for Enhanced/Engineered Geothermal Systems (EGS), albeit at significantly greater depths (say 4 to 5km), and in a very different geological setting to that of unconventional gas. Operators should be aware of the increased public, political and regulatory focus that may apply to this process when applied to geothermal developments. The differences (and similarities) in the requirements have been summarised in a fact sheet prepared by the European Geothermal Energy Council (EGEC, 2013).

Regulatory requirements to ensure that seismic risks are effectively mitigated in hydraulic fracturing operations (for shale gas) were announced by the Secretary of State for Energy on 13

December 2012 and require operators seeking consent under licences for hydraulic fracturing operations to manage seismic risks, including conducting a seismic risk assessment, creation of a 'frac' plan, and seismic monitoring.

3.5.9 Gold and silver

The Crown generally holds the rights to gold and silver, although in the past some rights were transferred by ancient charter in Scotland. Gold and silver mines are known as 'Mines Royal' and the Crown Estate grants exclusive options to take a lease of these for a specific area. These options must be obtained from the Crown Estate's Mineral Agent. Exploration and access rights must be obtained from the landowner.

3.5.10 Other minerals

Other minerals are in private ownership, and although there is no national licensing system for exploration and extraction, planning permission must be obtained from a mineral planning authority for their extraction.

3.5.11 Could Geothermal Heat be considered a 'Mineral'?

It is considered that geothermal heat is not a 'Mineral' as defined by the Town and Country Planning Acts as it is not a 'substance'.

This concurs with DECC's assessment that the heat which is the essence of geothermal energy is not itself capable of ownership.

3.6 Groundwater

Authorisation for groundwater abstraction (or discharge to groundwater) is required from the Scottish Environment Protection Agency (SEPA) in the form of a notification, general binding rule and / or licence. Although SEPA issues licences for some groundwater abstractions this is for compliance with relevant European, UK and Scottish legislation and environmental protection and is not considered to imply ownership of or rights to groundwater by the Crown or other body.

In Scotland, the landowner generally owns the right to abstract groundwater from the ground. The existing system of groundwater abstraction licences are primarily aimed at environmental protection, as opposed to heat resource protection, and do not specifically consider geothermal heat extraction.

It is noted that the introduction of heat into the water environment is included in "pollution" as defined in the Water Environment and Water Services (Scotland) Act 2003 (see Section 5 – The Environmental Regulatory Regime for Deep Geothermal Energy Developments).

3.7 Discussion & Conclusions

An outcome of the Project Stakeholder Workshop (Edinburgh, 31 October 2012) was that participants generally considered geothermal energy should be a state resource and therefore should be legally defined as such through a statutory resource licensing regime, to control and administrate geothermal development and protect the resource.

The fledgling geothermal industry in Scotland, comprising developers and potential investors, would also welcome clear definition and a licensing system.

It was also noted that there are potential parallels between the current ongoing development of the geothermal energy industry (currently at an early stage), and the early development of the oil and gas industry in the UK.

The uncertainty of ownership of geothermal resources is a potential risk for individual projects, which along with risks associated with geological uncertainty, gives rise to increased cost and can make it difficult to obtain sufficient finance to develop deep geothermal projects (see Section 7 – Costs, Financing & Benefits Assessment). It is noted that currently the geological uncertainty may be a bigger factor in lack of investor confidence than the lack of legal definition and a resource licensing system.

On review of the information provided by DECC, and also of ownership of other rights to resources in the ground (including mineral rights), it appears that geothermal energy resource ownership or right to exploit such resources is not currently legally defined in Scotland, nor indeed the wider UK.

Existing geothermal energy schemes in the Scotland, and in the wider UK, have not been subject to resource licensing as no such licensing system currently exists.

It is considered that the State (the Crown) does not currently have a claim on, or rights to, geothermal heat resources under land in private ownership under existing legislation. It is not currently possible for the State to specifically license exploration and / or exploitation of geothermal heat resources, except perhaps those in land which is owned by the Crown (including the onshore and offshore interests of the Crown Estate).

To allow legislation to be developed, what geothermal heat resources first need to be legally defined, To claim the ownership of or rights to geothermal heat resources, what actually constitutes the geothermal ‘resource’.

When the rights to oil and gas resources were established via the various UK Petroleum Acts (vesting of the rights to resources in the Crown), it was done on a UK-wide basis. Establishing the rights to ownership of geothermal resources could also be done on a UK-wide basis through

the UK Parliament. DECC has indicated that although it has considered this, it has not be undertaken as a priority.

It may be possible for the Scottish Parliament to independently establish the ownership of, or rights to, geothermal heat resources in Scotland, however, it is considered that this could potentially require transfer of reserved powers under the Section 30 of Scotland Act 1998 from the UK Parliament to the Scottish Parliament and would therefore not be completely unilateral.

3.8 Recommendations

It is recommended that, to give certainty to the legal ownership status of geothermal resources, reduce project financing risks and costs and therefore encourage commercial development, the legal ownership of geothermal energy resources should be established to allow a geothermal resource licensing system to be established. It is considered that this can only be undertaken by amending existing primary legislation or introducing new primary legislation.

It is recommended that the Scottish Government liaises with DECC to determine whether establishing legal ownership (and introduction of a licensing system) can now be taken forward as UK priority, or alternatively, how this can be undertaken by the Scottish Government.

Dependent on how legal ownership is established will influence who is responsible for licensing the resource, i.e. DECC on a UK-wide basis or the Scottish Government for Scottish resources. It is anticipated that the Scottish Government would prefer to have the right to license Scottish geothermal resources independently.

Options for potential legal definition and licensing regimes are discussed in Section 4: Potential Geothermal Resource Licensing Options.

Potential Geothermal Resource Licensing Options

4 Potential Geothermal Resource Licensing Options

4.1 Introduction

As discussed in Section 3, although it is controlled by existing development management (planning) and environmental regulation, there is currently no resource licensing system in place for geothermal energy developments in Scotland.

Existing resource licensing systems and the requirements for development of a Scottish geothermal resource licensing system are reviewed below, and recommendations have been made for such a system.

4.1.1 Is resource licensing required for geothermal energy developments?

The traditional energy resources in the ground (mainly coal, and oil and gas) are controlled by a system of state licensing. The purpose of this is to control the exploitation of these nationally-important resources in an ordered and responsible manner (including those under third-party land), provide exclusive rights to the developer to exploit the resources within the licensed area and provide income for the State.

As stated in Section 3, the lack of a resource licensing system is seen as a significant barrier to investment in commercial exploration and development of geothermal resources in Scotland, and other parts of the UK, as it potentially discourages private investment in deep geothermal projects as it is a commercial risk. Developers and investors want security of tenure and exclusive rights to the resource that they are intending to invest in exploring and developing.

It is noted, including from discussion at the stakeholder workshop, that the current primary risk facing developers and investors in the proposed deep geothermal projects (EGS) in England is actually the risk associated with geological uncertainty, and that the lack of a licensing system is secondary to this. However, to allow the geothermal industry to develop, it is considered important to have some form of licensing system in place in the medium term, and also perhaps to have some sort of interim measure in place in the short term.

4.1.2 Definition of Resource Licensing

Where the term ‘licence’ is used in this Section of the report, unless otherwise stated, it refers to a resource licence which gives rights to explore or exploit a particular resource. It does not refer to other types of environmental or other licence, authorisation, registration or permit that may be required elsewhere under statute (see Section 5 - The Environmental Regulatory Regime for Deep Geothermal Energy Developments).

4.2 Review of Existing Resource Licensing

The various aspects of existing UK resource licensing systems (non-geothermal) and international resource licensing systems (geothermal specific) have been reviewed in order to

assess their suitability for adoption or amendment, or whether a separate new regime is required. Recommendations for geothermal resource licensing have been made following consideration of the various options. Fuller review of existing potentially relevant resource licensing systems is included in Appendix A and is briefly summarised in the following sub-sections.

4.2.1 Petroleum Licensing in the UK (including 'unconventional' gas resources)

The Department of Energy and Climate Change (DECC) issues Petroleum Licences. The PEDL (Petroleum Exploration & Development Licence) for onshore licensing was introduced in 1996 to reduce bureaucratic burden of issuing a series of licences.

Potentially relevant features of Petroleum Licenses include (see Appendix A):

- Rentals - an annual charge, due each year on the licence anniversary and charged at an escalating rate on each square kilometre the licence covers at that date.
- Terms - licences are valid for a sequence of periods, known as 'terms', designed to comprise the typical life cycle of a field: exploration, appraisal, production.

The landward PEDL (onshore) licence confers the right to search for, bore for and get hydrocarbons, but do not confer any exemption from other legal/regulatory requirements such as any need to gain access rights from landowners, health and safety regulations or planning permission. In particular, nothing in part I of the Act confers, or enables the Secretary of State to confer, any right to enter on or interfere with land (see section 9(2) of the Act. However, section 7(1) of the Act applies the Mines (Working Facilities and Support) Act 1966 in England, Wales and Scotland for the purpose of enabling a licensee to acquire such ancillary rights as may be required for the exercise of the rights granted by the licence.

4.2.2 The Coal Authority and Minewater Heat Recovery Access Agreement (MHRAA)

The Coal Authority has specific statutory responsibilities associated with licensing coal mining operations and issues related to past coal mining activities in Great Britain. The Coal Authority also has obligations to consider the implications on existing and future coal mining (and the potential for coal bed methane exploitation) of any activity which intersects, disturbs or enters any of the Coal Authority's coal interests. Such activities require the prior written authorisation of the Coal Authority in the form of either a Licence, Agreement, or Permit, depending upon the activity to be carried out.

The Coal Authority has introduced a form specific to geothermal development projects that extract heat from minewaters, a 'Minewater Heat Recovery Access Agreement' (MHRAA). The Coal Authority grants two types of MHRAA, namely:

- an Access Agreement relating to Minewater Heat Recovery at a single site, with a maximum agreement area of 500 hectares, where all other rights and permissions are in place or applied for; or
- an Access Agreement relating to a larger area, with a maximum size of 2,000 hectares, where the intention is to evaluate the potential for project(s), with subsequent Supplemental Agreements required for each borehole site within this overall area.

It is noted that the MHRAA is an access agreement granted by the Coal Authority, largely to protect its assets, and it does not specifically grant a right or licence to the geothermal heat energy itself. This is presumably because the ownership of the heat is legally undefined (see Section 3 - The Ownership of Geothermal Resources in Scotland).

The MHRAA does not absolve the applicant from obtaining all other necessary rights, including surface access rights, permissions and consents.

4.2.3 Existing Licensing Systems in Other Countries

Various licensing systems are already in place in different countries and states around the world. Holroyd and Dagg (2011) carried out an inter-jurisdictional review of geothermal energy legislation (see Appendix A). This review provides a useful summary of some of the legal frameworks that have been put in place in different countries, including the United States, Canada, Australia, New Zealand, Iceland, Italy and Germany.

The Irish Government has also developed, and is proposing to introduce, specific legislative proposals in respect of geothermal energy (see Appendix A). It is currently proposed that the Geothermal Energy Development Bill will be published in 2013, following publication of the Minerals Development Bill, on which certain aspects of it are based.

It is acknowledged that the Irish Government has put considerable effort into developing legislation for licensing of geothermal resources that it intends to introduce in the near future. It is considered that although the proposed Irish legislation is based on their proposed new minerals legislation (as opposed to oil and gas legislation), that there are many common elements between the Irish and Scottish situation and that there are useful lessons to be learnt from the technical elements of the proposed Irish legislation when developing either UK or Scottish legislation.

4.3 Definition of geothermal energy resources

As discussed in Section 3 – The Ownership of Geothermal Resources in Scotland, and stated by DECC, it is considered that a clear definition of what comprises a geothermal energy resource is important in establishing ownership of the resource.

The definition will determine whether geothermal energy is defined in legislation as a mineral, water or heat/energy (see below). This in turn determines whether existing legislation can be used or amended to control the resource, or whether new legislation is required.

An example of a simple definition of geothermal energy is that used by the European Geothermal Energy Council (EGEC): “energy stored in the form of heat beneath the surface of the (solid) earth”.

Other definitions have been used in various countries and jurisdictions around the world, depending on how geothermal energy has been controlled through legislation.

As previously discussed, geothermal energy is not currently defined in Scottish or UK legislation and would require definition in new primary legislation or amendment of existing legislation to create a licensing regime.

4.4 Geothermal Resource Licensing Legislation

The legislative review by Holroyd and Dagg (2011), summarised in Appendix A, found four main resource classifications for legislative approaches to controlling geothermal resources:

- Petroleum;
- Minerals;
- Water resources; or
- Geothermal-specific.

Legislation relating to petroleum, minerals and water resources already exists in the UK and Scotland. The legislation relating to petroleum and minerals is considered to be most relevant to potential resource licensing.

4.5 Administration of Geothermal Energy Resource Licensing

Globally, the administration of geothermal energy resource licensing has been allocated in line with how geothermal energy has been classified and subsequent legislation.

4.6 Classification of geothermal energy resources

As part of the definition of geothermal energy, the resources that legislation will apply to are in most instances classified by one or more of the following in various other countries:

- Depth(s);
- Temperature threshold(s);
- End use;
- Power or heat capacity output;

- Geological type of resource - hydrothermal / petrothermal; and / or
- Geothermal technology.

Many countries use a range of greater than 400 metres to up to 1,000m depth to define shallow geothermal, with deep geothermal defined as greater than 1,000m depth.

Determining the classification of geothermal energy is key in determining how, when and where legislation will be applied.

Basing classification on the predicted, and to date largely untested, available geothermal temperatures, output types or resource capacity may be inappropriate and lead to over-complication. Further, basing classification on the geological type of resource may also be complicated due to the unique geological nature of individual resources.

The simplest basis of classifying geothermal energy resource is considered to be to use depth thresholds as this is an absolute. This is generally consistent with the nature of the available resources in Scotland which can be broadly classified by depth:

- <200m depth – Ground Source Heat Pumps
- <1,000m depth – shallow geothermal, Mine Waters, Shallow Aquifers (all with heat pumps)
- >1,000m depth - Hot Sedimentary Aquifers (including disused oil wells)
- >3,000m depth - Hot Fractured Rock / Hot Dry Rock / Enhanced Geothermal Systems

4.7 Fees, Leases, Rents and Royalties

In countries and jurisdictions with existing geothermal legislation a system for charging fees, leases, rents, tenures and / or royalties is generally included in the legislation.

4.7.1 Fees

A licence application fee is usually charged. This varies between different jurisdictions from nominal amounts (the equivalent to say several hundred pounds), to more significant amounts (the equivalent to say tens of thousands of pounds).

4.7.2 Leases and Rents

Appropriate leases give the developer confidence to invest in the development of the resource.

The lease period is usually set at an initial period (for example 10 years) with options for a defined and limited number of extensions (for example 5 years each). Options for extensions would usually be based on satisfactory performance of the developer or operating company during the initial lease period.

Leases can be applied to both exploration and production phases of development. In the examples from other countries and jurisdictions, an exploration bond is required, which is either a fixed amount or is dependent on the size of the lease area.

Annual rents can be applied to cover the leased area. In the examples from other countries and jurisdictions, relatively low rents are initially applied (of say US$1 to US$2 per acre per year), that increase steadily over the tenure period (to say US$10 per acre per year after 10 years).

As an alternative or in addition to the rents, if their is sufficient competition to warrant it, then the license area lease could be sold by competitive bid.

4.7.3 Royalties

Royalties are potentially be paid at a pre-defined rate on electricity and or heat produced to reflect the use of a national resource for profit by private developers.

4.8 Key Requirements for a Potential Geothermal Licensing Regime for Scotland

Based on the reviews of existing relevant resource licences in the UK and the geothermal licensing regimes for other countries, and the particular requirements relevant to Scotland, key requirements for a geothermal resource licensing system are considered to be:

- Clear definition of what comprises a geothermal energy resource.
- Classification of geothermal energy resources (by depth), including those that may be exempt or given permitted rights.
- Definition of geographical areas of licences (or ‘blocks’).
- A phased system of licence terms for the various phases of exploration, development and production.
- Exclusive rights for exploration of resources and production of energy.
- Granting of initial licences to parties who can demonstrate sufficiently that they are already investing in exploring or producing from a particular geothermal resource.
- Ancillary rights (such as third party land access rights).
- A system of fees, rentals (‘rents’) and / or royalties.
- Compatibility with existing development management (planning), consenting and permitting regimes and processes, which shall still apply.
- Compatibility with The Coal Authority’s Licences, Agreements, and / or Permits (if applicable).
- Relevant exclusions or general rules for applicable schemes, including for existing shallow geothermal and GSHP schemes.

- A suitable administrative body.

4.9 Options for Geothermal Licensing Legislation

4.9.1 Identification of Options for the Introduction of Geothermal Licensing Legislation

The following options for the potential introduction of a geothermal licensing regime have been identified:

- Option 1 – Do nothing (do not introduce any new or amended legislation).
- Option 2 – Amend existing legislation.
- Option 3 – Create specific geothermal resource licensing legislation.

Under Option 2 three potential sub-options have been identified, as follows:

  - Sub-Option 2A - Amend existing Petroleum legislation by including geothermal energy into the legislation.
  - Sub-Option 2B - Amend existing Minerals and / or Mining legislation by amending the description of minerals in the legislation to include geothermal energy.
  - Sub-Option 2C – Amend existing Water Resources legislation by including geothermal energy into the legislation.

4.9.2 Assessment of Key Potential Options for Geothermal Licensing Legislation

The assessment of key potential options identified is summarised in Table 4.1, including likely costs and timing and advantages and disadvantages for each option.

Table 4.1 Assessment of Key Potential Options

	Impacts		
Key Option	**Costs & Timing**	**Advantages**	**Disadvantages**
Option 1 – Do nothing	None. Indirect cost of under-investment in geothermal industry.	None	Unlikely to promote investment in geothermal energy, under-utilisation of the resource. Does not address indentified key requirements.
Sub-Option 2A - Amend existing Petroleum legislation	Relatively moderate cost for drafting amended legislation, parliamentary process and administration. Moderate time implication.	Financial saving over drafting new legislation. Similarities in exploration and production techniques. Experienced potential administrative body in place (DECC).	Potential complications in incorporating geothermal energy, possibly making it subject to onerous and inappropriate regimes. Potential difficulties in adequately addressing indentified key requirements.
Sub-Option 2B - Amend existing Minerals and / or Mining legislation	Relatively moderate cost for drafting amended legislation, parliamentary process and administration. Moderate time implication.	Financial saving over drafting new legislation. Similarities in exploration techniques. Experienced potential administrative bodies in place (CA/DECC, local authorities).	Potential complications in incorporating geothermal energy, possibly making it subject to onerous and inappropriate regimes. Potential difficulties in adequately addressing indentified key requirements.
Sub-Option 2C – Amend existing Water Resources legislation	Relatively moderate cost for drafting amended legislation, parliamentary process and administration. Moderate time implication.	Financial saving over drafting new legislation. Some similarities in water abstraction / discharge. Geothermal energy already incorporated in water regulations in relation to environmental controls (abstraction / discharge rates, heat identified as a potential pollutant).	Potential complications in incorporating geothermal energy, possibly making it subject to onerous and inappropriate regimes. SEPA are not specialists in energy source regulation. Unlikely to adequately address key indentified requirements.
Option 3 – Create specific geothermal resource legislation	Relatively high cost for drafting new legislation, parliamentary process and administration. Potentially moderate to high time implication.	Ability to address indentified key requirements. Specific nature reduces compliance burden and thereby promoting investment in geothermal energy. Geothermal energy can be separately and uniquely defined avoiding conflicts with incorporating it in existing legislation. Can be made applicable to include possible future development of offshore resources. Shallower resources can be exempted to avoid over-regulation.	Relatively high cost, moderate to high time implication.

4.9.1 Discussion of Options

Option 1 – Do Nothing

The ‘Do Nothing’ option is unlikely to actively promote investment in geothermal energy in Scotland leading to under-utilisation of the resource. This is not considered to be in line with renewable energy policy for Scotland, and in particular will lead to a missed opportunity for geothermal to contribute towards renewable energy targets in the coming years.

Outcome: Not Recommended

Option 2 – Amend existing legislation

The main advantages of amending existing legislation are the relatively moderate costs and the relatively short timescale compared to drafting new legislation. For sub-option 2A or 2B (amend existing petroleum, minerals or mining legislation), if DECC were to be the regulator then they are experienced in regulating energy sources.

The main disadvantage is potential complications in incorporating geothermal energy into existing legislation, possibly making it subject to onerous and inappropriate regimes.

Outcome: Not Recommended

Option 3 – Create specific geothermal resource licensing legislation

The main advantage of creating new legislation means that it can be drafted to deal with specific requirements of geothermal energy and avoid the use of potentially inappropriate or onerous existing legislation. However, drafting and enacting new legislation would take significant time and financial resources, including the time it takes to prepare and enact that legislation, including consultation, drafting and its passage through parliament

Other risks include competing political priorities, and that the timescales involved mean that investment in geothermal energy is channelled elsewhere, the potential contribution to reducing carbon emissions is lost and the opportunity for skills transfer from Scotland's oil and gas sector is also lost.

Outcome: Recommended

4.9.2 Recommended Option for Geothermal Licensing Legislation

It is recommended that Option 3, creation of specific geothermal resource licensing legislation is adopted.

It is anticipated that given the likely timescale involved in drafting and enacting new and specific legislation (possibly several years), interim measures are required to encourage investment in the short to medium term (see below).

4.10 Application of Geothermal Resource Licensing to Shallow Resources

Renewable energy policy in Scotland, including renewable heat, encourages de-centralised and local generation of energy. It is therefore considered that the Scottish Government would not want to inhibit the take-up of GSHP technology by burdening such projects with legislative requirements. In addition, it is considered that it would be undesirable to preclude use of GSHP in areas licensed for deep geothermal developments which will be unaffected.

From experience, most GSHP well boreholes are <200m deep, 100m deep being a more typical depth, with larger capacity systems using an array of wells to get the required length of pipe in

the ground for required capacity of the system due to the costs of drilling increasing with depth. Some GSHP wells could be greater than 200m depth.

It is recommended therefore that any legislation could be drafted to allow exemption of shallower geothermal resources including GSHP applications or development subject to general rules, but that they would still be subject to all other appropriate planning and regulatory regimes, and other legal requirements. Definition is therefore required to differentiate between 'shallow' and 'deep' geothermal resources.

For financial reasons (the scale of the investment, technical risk and value for money), it is considered that the best potential for development of geothermal energy in Scotland in the short to medium term is heat from relatively shallow geothermal resources (i.e. those less than <1,000m but often much shallower), including the use of heat pumps where appropriate.

It is anticipated that GSHP schemes and shallower geothermal schemes with relatively modest outputs will form the vast majority of developments in Scotland in the near future. Exempting these from a licensing system has several potential advantages, including reducing the relative administrative and cost burden on both developers and regulators, and incentivising local-scale developments, including as part of heat networks in line with renewable heat policy in Scotland.

Conversely, it is considered that exploitation of deeper geothermal resources, that offer potential for heat and power in the medium to longer term, due to the petrothermal resources in Scotland being currently a largely unproven resource and EGS being an evolving and developing technology which has not been proven on a commercial scale do require a specific scheme. Due to the level of investment required, and the risks related to geological uncertainty, the number of deeper geothermal developments in the future is always likely to be much fewer than the number of shallower developments.

Shallower geothermal developments exempted from future potential resource licensing (or subject to general rules) would continue to be controlled by relevant legislation and regulations, including the following:

- Planning;
- CAR (the Controlled Activities Regulations); and
- The Coal Authority Licenses, Permissions and Agreements (if applicable).

DECC's proposed RHI for 'deep' geothermal only applies to projects >500m depth.

4.10.1 Identification of Options for Depth Classification

The following options for have been identified for classifying geothermal resources by depth, based on various accepted definitions:

- Option 1 – exempt geothermal resources at <100m depth as being 'shallow', in accordance with the existing Scottish Planning Guidance for 'deep' geothermal being >100m depth.

- Option 2 – exempt geothermal resources at <200m depth as being ‘shallow’.
- Option 3 – exempt geothermal resources at <500m depth as being ‘shallow’, in accordance with the definition of ‘deep’ geothermal for the RHI.
- Option 4 – exempt geothermal resources at <1,000m depth as being ‘shallow’, in accordance with some existing international definitions (and also the general consensus at the stakeholder workshop), that >1,000m depth constitutes ‘deep’ geothermal.

The assessment of potential options identified is summarised in Table 4.2, including advantages and disadvantages for each option.

Table 4.2 Assessment of Potential Options to Define ‘Shallow’ and ‘Deep’ Resources

	Impacts		
Key Policy Option	**Costs & Timing**	**Advantages**	**Disadvantages**
Option 1 – apply legislation to geothermal >100m depth	N/A	Consistency with existing Scottish Planning Guidance.	Not a widely accepted definition. Existing and likely future GSHP-type schemes reach depths of >100m and would be burdened with a licensing system, although exemptions could be included.
Option 2 – apply legislation to geothermal >200m depth	N/A	Excludes the vast majority of GSHP-type projects. Concentrates licensing on deeper schemes and does not place resource licensing burden on smaller relatively shallow schemes.	Not a widely accepted definition. Existing and likely future GSHP-type schemes may reach depths of >200m and would be burdened with a licensing system, although exemptions could be included.
Option 3 – apply legislation to geothermal >500m depth	N/A	Consistency with the current proposed DECC RHI threshold for ‘deep’ geothermal. Concentrates licensing on deeper schemes and does not place resource licensing burden on smaller relatively shallow schemes.	Not a widely accepted definition. The proposed RHI will still apply to schemes >500m depth, regardless of licensing classification.
Option 4 – apply legislation to geothermal >1,000m depth	N/A	In accordance with some existing definitions and general stakeholder consensus. Concentrates licensing on larger schemes and does not place resource licensing burden on smaller relatively shallow schemes.	This would also exempt many potential geothermal schemes, including those in mine workings which are generally <1,000m depth in Scotland. The gap between shallow GSHP schemes (typically <200m depth) and the 1,000m depth limit is large.

It is recommended that Option 2 is adopted, apply legislation to geothermal resources >200m depth, potentially with exemptions included for closed-loop GSHP-type systems.

4.11 Withdrawn Amendment to the Proposed Energy Bill

It is noted that in early 2011, the UK Government considered an amendment to the Energy Bill as proposed by Lord Teverson (Amendment 35, Tuesday 8 February 2011) in the House of Lords.

The proposed amendment was for the Secretary of State to develop and introduce a licensing system and regulations for the exploitation of deep geothermal sources, with wording as follows (see http://www.publications.parliament.uk/pa/ld201011/ldhansrd/text/110208-gc0001.htm).

After Clause 97, insert the following new Clause-

"Geothermal power

(1) Within eighteen months of this Act coming into force, the Secretary of State shall, after a period of consultation with industry, geological experts, the devolved administrations, local authorities, energy producers and other interested parties, put into place for the United Kingdom a licensing system and regulations for the exploitation of heat from deep geothermal sources for both the direct use of that heat and for the generation of electricity.

(2) The licences shall relate to-

(a) individual geographically delineated areas on land;

(b) the heat held by rocks greater than one kilometre below the surface.

(3) Licences shall give exclusive exploration and production rights for the purpose of energy production from geothermal sources, both direct heat and electricity generation, to the licensee, for that area, and for a specific period of time.

(4) The Secretary of State shall lay down regulations for the method of allocation of licences to those organisations wishing to explore or exploit those resources, or both.

(5) The Secretary of State shall undertake the first round of allocations within six months of the licensing regulations under subsection (1) being approved.

(6) Any organisation already undertaking exploration or exploitation from geothermal sources within the United Kingdom, in that they have already undertaken, at the time the licensing regime comes into force, boring for the purpose of exploiting geothermal heat to below one kilometre, shall be entitled to hold the first licence awarded for that licence area, and any licence fee or other consideration for that licence area as a part of the licensing regime will then be determined by arbitration under rules determined by the Secretary of State reflecting the fees or other consideration paid for licences deemed to have similar potential.

(7) The holding of a licence for the exploration or exploitation of deep geothermal heat, or both, shall not convey any automatic rights in terms of planning permissions for surface development, or give any rights in terms of surface access."

The amendment was however withdrawn and was not included in the Energy Bill (which received Royal Assent in October 2011, and became the Energy Act 2011). It is not clear from the record why the amendment was withdrawn, however, there does seem to have been some discussion with the 'Minister' (presumably a Minister from DECC).

4.12 The Proposed Form of a Geothermal Resource Licensing Regime for Scotland

The proposed form of a geothermal resource licensing regime for Scotland must address the key requirements identified in Section 4.8.

Based on review of the requirements and existing resource licensing regimes, it is considered that the general form of the UK petroleum licensing regime for onshore developments (PEDL) may be suitable for application to the proposed 'Geothermal Exploration and Development Licence' ('GEDL').

It is considered that this format would make GEDL suitable for licensing of both potential onshore, and potential future offshore, geothermal developments.

Definition of what comprises a geothermal energy resource

It is recommended that a simple definition of geothermal energy is used, for example: "energy stored in the form of heat beneath the surface of the (solid) earth" (as used by EGEC) or similar.

Classification of geothermal energy resources

As discussed above, it is recommended that any legislation could be drafted to allow development geothermal resources <200m deep subject to general rules or exemptions, for example for closed-loop GSHP-type systems that are unlikely to significantly effect other geothermal developments. The option to license shallow resources in the future, if it proves necessary, would therefore be retained. Similarly, exemptions could potentially be included.

Geographical definition of licence areas

It is anticipated that the definition of the geographical extent of licensed areas (or 'blocks' in PEDL terminology) would actually differ from Petroleum Licensing due to the differing nature of the resource.

It is anticipated that blocks would not be released in licensing rounds as in Petroleum Licensing, as the exact location of the best resources is not currently well defined.

It is instead anticipated that the developer would instead indentify a potential resource and apply to licence a particular area of interest for geothermal exploration, with later development and production phases.

The geographical extent of the area would initially be that anticipated to be the full sub-surface extent potentially effected by the development, as predicted by modelling prior to exploration. This area would then be subject to refinement following the exploration stage and more accurate modelling.

Of particular concern for potential investors is the security of the resource from other potential developments. Under the proposed GEDL, any developers would need to demonstrate that the effects to any existing licensed areas from their proposed development would be negligible.

Phasing of licence terms

The lease periods (or ‘terms’ in PEDL terminology) would potentially be in three phases, to allow phased development of the resource. It is therefore recommended that leases for the licensed area are introduced as part of any Primary legislation. The preliminary proposed terms are indicated in Table 4.3. These are based on the expected working life of the geothermal plant.

Table 4.3 Potential Phases of Geothermal Licensing

Term	Life cycle of field	Preliminary Proposed Term Duration	Comment
Initial	Exploration	5 years	Initial site finding, geophysical surveys, including all necessary planning permissions and environmental permitting.
Second	Appraisal and Development	5 years	Securing investment / finance, initial exploratory / production well(s), other production wells
Third	Production & Decommissioning	25 years	Production. Potentially subject to consecutive extensions.

Exclusive rights for developers

The provision of an exclusive secure tenure for developers is considered to be an important component in providing investor confidence and thereby encouraging investment in geothermal energy. The license would grant the exclusive rights to develop the resource within the defined area for the licence term, and subject to satisfactory progress.

It is anticipated that the legislation would allow for granting of initial licences to parties who could demonstrate sufficiently that they are already investing in exploring or producing from a particular geothermal resource so as not to disadvantage existing or proposed schemes.

Ancillary Rights

It is anticipated that under a proposed GEDL the Secretary of State (or a nominated Minister of the Scottish Parliament) would have the ability under the proposed Primary legislation (some form of 'Geothermal Energy Act') to confer the right to search for, bore for and recover (extract) geothermal energy, but would not confer any exemption from other legal or regulatory requirements such as:

- any need to gain access rights from landowners
- health and safety regulations
- planning permission from relevant local authorities.
- environmental regulatory requirements.

With regard to any required access onto third-party land for exploration or production, a proposed Geothermal Energy Act could be developed to either give the licensee rights to enter on or interfere with land but this may cause difficulties in legislation. Alternatively, it may be possible (as for PEDL) for a Geothermal Energy Act to apply the Mines (Working Facilities and Support) Act 1966 in England, Wales and Scotland for the purpose of enabling a licensee to acquire such ancillary rights as may be required for the exercise of the rights granted by the licence.

It is not anticipated that access onto third party land would be common, as geothermal developments can operate from a single relatively small surface site area. However, the above would allow for access in exceptional circumstances, say to prevent monopolisation of a resource by a single landowner.

Fees, terms, rentals and / or royalties

Each licence could carry an annual charge (rental), potentially at an escalating rate on each hectare that the licence covers at that date to encourage licensees to focus licensees of areas that they decide to develop, and also to surrender areas that they don't want to exploit.

Licences would be valid for a sequence of terms (see above). These would be designed to comprise the typical life cycle of a geothermal field comprising exploration, appraisal and production.

It is anticipated that each licence would expire automatically at the end of each term, unless the licensee has sufficiently progressed to warrant a move into the next term. However, in order to reduce risks to developers and encourage investment, it is recommended that under a proposed GEDL, that it would be possible to apply to extend the length of the licence terms before they expire, if it could be proven by the licensee that circumstances beyond their control had caused delay. The length of extension could be fixed on a case-by-case basis.

Licensees would be entitled to surrender a licence, or part of the acreage covered by it, at any time. It is anticipated that licensees would be positively encouraged to surrender acreage if they did not intend to develop it.

It is recommended that a provision is made in developing geothermal licensing legislation that allows royalties and rents to be charged, if desirable in the future, but that the initial level of royalties should be set at zero and rents at a nominal level. This to reflect the current early development of the industry and to encourage investment in geothermal energy as a renewable (low carbon) technology. For the same reason, royalties are not currently charged in Germany.

It is anticipated that a licence application fee would be charged to cover, or at least part-cover, the cost of administration and assessment of the application.

The relevant policies and principles for fees, leases, royalties and any other levies would need to be laid out in the Primary legislation. Determination of the level of these is beyond the scope of this report. Appropriate initial amounts should be proposed and agreed after consultation with industry on the proposed legislation.

Compatibility with existing legislation

The geothermal licensing legislation must be developed to be compatible with existing legislation and regulatory requirements, including development management (planning), consenting and permitting regimes and processes, which shall still apply. In particular, compatibility with The Coal Authority’s Licences, Agreements, and / or Permits would be required within coal mining areas.

It is anticipated that the licence conditions would require all legislative and regulatory requirements to be met, for the appropriate development term, before the licence could be validated.

Administrative Bodies

As discussed in Section 3 - The Ownership of Geothermal Resources in Scotland, administration may be on a UK-wide or Scottish basis, and will depend on the form any licensing regime.

The existing Petroleum Licensing regime in administered by DECC on a UK-wide basis.

If the proposed GEDL is to be based on Petroleum Licensing, it may appropriate for DECC to also administer it is considered that they will have the most relevant experience. The Scottish Government may wish, however, for control over the proposed GEDL in Scotland (onshore and offshore).

It would then be a matter for the Scottish Government to determine which department, agency or public body would carry out the administrative duties.

The division of responsibilities between the UK Government and Scottish Government for a future potential licensing regime is beyond the scope of this report.

4.13 The Timeline for Geothermal Industry Development in Scotland

A possible timeline for geothermal industry development in Scotland is indicated in Table 4.4. This is based on similar predicted timescales in the timeline in the Australian Geothermal Industry Technology Roadmap (Commonwealth of Australia, 2008) and mainly relates to projects aiming to generate power (electricity). Heat-only projects could start to be implemented in areas with the best available information immediately.

Table 4.4 Possible Approximate Timeline for Geothermal Industry Development in Scotland (for HDR type projects)

Year	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Later
	2013	2014	2015	2016	2017	2018	2019	2020	2021	20??
Exploration										
Non-Intrusive										
Intrusive										
Drilling and Reservoir Development										
R&D										
Testing										
Power Generation										
Demonstration										
Small Scale Commercial										
Larger Scale Commercial										
Legislation										
Drafting & Enactment										
Interim Period										

4.14 The Interim Position for Licensing

It is anticipated that given the likely timescale involved in drafting new and specific geothermal resource licensing legislation (several years), interim measures are required to encourage commercial investment in the short term and medium term.

It may be appropriate to follow a two stage approach to legislation, initially creating relatively simple interim exploration and development legislation, as an amendment to existing legislation, to be replaced at a later date with more comprehensive and stand-alone Geothermal Energy Act (covering exploration, development and production), as the industry develops and matures. A similar two-stage approach was followed in the state of Queensland in Australia (Holroyd and Dagg, 2011) with an initial ‘Geothermal Exploration Act’ (2004) and a later ‘Geothermal Energy Act’ (2011).

An alternative mechanism is still required in the intervening interim period, until either formal interim or full legislation is introduced.

Two potential options for indirectly controlling geothermal development through existing legislation and regulations:

- groundwater abstraction licences, and / or
- the development management (planning) regime.

It is important to note that neither of these options would formally license the geothermal resource itself, they would however allow a level of control on development and provide some security for developers.

Groundwater abstraction licences are issued by SEPA. Groundwater abstraction for geothermal projects in Scotland do not currently need a groundwater abstraction licence if they comply with the conditions of the relevant general binding rules (GBR3 and GBR17). A condition of GBR17 is that the volume of water abstracted but and not returned must not exceed $10m^3$ per day (see Section 5 - The Environmental Regulatory Regime for Deep Geothermal Energy Developments), in other words as long as the same volume of water abstracted for geothermal purposes is returned (and subject to the other conditions) an abstraction licence is not required.

It is noted that in England, the Environment Agency are regulating deep geothermal energy through abstraction licences for any schemes abstracting more than $20m^3$ of water per day. The EA note in their position statement (EA, 2011) that their abstraction licence “protects the right to water quantity, not heat. If we grant a new licence to another nearby or competing scheme, our primary duty will be to prevent the loss of water available for abstraction under the existing licence or other protected rights to abstract water. We will not be liable for any loss of heat if a new scheme takes heat away from an existing scheme”.

Control of geothermal developments through groundwater abstraction licences in Scotland would therefore require a change to GBR17 in the Schedules to CAR (The Water Environment (Controlled Activities) (Scotland) Regulations 2011) to require an abstraction licence for geothermal energy projects. It is considered that this would take a significant period of time and therefore is unsuitable for a short term interim measure.

Geothermal development could potentially be controlled in the interim to some extent through the development management (planning) regime, namely assessment of cumulative effects in Environmental Impact Assessment (EIA) (see Section 5 - The Environmental Regulatory Regime for Deep Geothermal Energy Developments). The main advantage of using the development management approach is that any later adjacent proposed geothermal development(s), that also require an EIA, would need to prove prior to planning consent being granted, that there was no significant cumulative effect on an existing scheme that could be detrimental to its operation.

The interim system would require new planning guidance on the application of EIA to proposed geothermal developments, including consideration of the whole of the three-dimensional volume

predicted to be effected by the development and not just the surface footprint of the site (drilling) compound ('red line' planning boundary).

4.15 Conclusions

A clear definition of what comprises a geothermal energy is vital in establishing ownership of the resource and determines whether it is defined in legislation as a mineral, water or heat/energy. This in turn determines whether existing legislation can be used or amended to control the resource, or whether new legislation is required. Geothermal energy resources are not currently defined in Scottish or UK legislation and does not come under existing legislation.

It is expected that the rights to geothermal energy resources would be claimed on a UK-wide basis and rights then licensed by a UK Government agency (for example DECC), or possibly the powers for Scotland could be 'transferred' to the Scottish Government.

From the review of legal ownership and existing licensing regimes, it is considered that adoption or amendment of existing licensing regimes would potentially be problematic and creation of new, specific legislation is the preferred option. Key requirements for a potential geothermal licensing regime have been identified.

It is anticipated that given the likely timescale involved in drafting new and specific geothermal resource licensing legislation (several years), interim measures are required to encourage commercial investment in the short term and medium term.

It may be appropriate to follow a two stage approach to legislation, initially creating relatively simple interim exploration and development legislation, as an amendment to existing legislation and to be replaced at a later date with more comprehensive legislation as the industry develops and matures.

In the intervening period before any amended or new legislation could be introduced, geothermal development could be controlled through the development management (planning) regime, and / or groundwater abstraction licences. Changes would be required to planning guidance relating to the application of EIA and / or the requirements for groundwater abstraction licences in the CAR (GBR17, Schedule 3) if these were to be used for control.

The enactment of geothermal resource licensing should be such so as not to inhibit the take-up of GSHP technology.

4.16 Recommendations

It is recommended that new primary legislation should be introduced, a proposed 'Geothermal Energy Act', to include claim ownership of geothermal resources and implement a licensing system for geothermal resources.

It may be appropriate to follow a two stage approach to legislation, initially creating relatively simple interim exploration and development legislation, as an amendment to existing legislation,

to be replaced at a later date with more comprehensive and stand-alone legislation, as the industry develops and matures.

It is recommended that the Scottish Government, in conjunction with DECC, reviews the potential political opportunities and timescales for introduction of the proposed Geothermal Energy Act, and potential interim legislation.

It is recommended that geothermal resources shallower than 200m depth should be either exempted from licensing or made subject to general rules.

To encourage commercial investment in the short term, it is recommended that in the intervening period before any amended or new legislation can be introduced, geothermal development is controlled through the development management (planning) regime through EIA, and / or groundwater abstraction licences. Some changes would be required to enable this. It is recommended that SEPA are consulted by the Scottish Government regarding this issue as they would be the primary consultee for relevant EIA issues and also administer groundwater abstraction licensing.

Environmental Legislation, Regulations and Permitting for Deep Geothermal Energy Developments

5 The Environmental Regulatory Regime for Deep Geothermal Energy Developments

5.1 Introduction

Commercial confidence and therefore investment in development can be affected by uncertainty surrounding the legislative regime applicable to development activities and real (or perceived) restrictions imposed by such legislation.

In order to identify relevant legislation and increase certainty regarding its application, a review of existing environmental legislation and permitting requirements applicable to deep geothermal energy developments in Scotland has been undertaken. This will assist in ensuring that exploitation of deep geothermal resources complies with existing environmental legislation and environmental permitting requirements is of fundamental importance.

An assessment of the adequacy and applicability of the existing environmental legislation and permitting requirements in controlling deep geothermal energy developments in Scotland has also been undertaken, in order to determine whether these are overly or under-restrictive and whether new or amended legislation is required.

This section of the report therefore presents a review of relevant environmental legislation and permitting (consenting) requirements and briefly summarises the key environmental legislation relevant to deep geothermal activities, comments on its current relevance to likely activities and where necessary makes recommendations for new or revised legislation and policy changes where applicable.

This review is presented as an examination of the principal environmental provisions as well as making reference to legislation that deals specifically with terrestrial or marine exploitation scenarios, as appropriate.

Reference to the term ‘Licence’ in this section, unless otherwise stated, refers to regulatory licences, permits, consents or other permissions and does not imply legal ownership or a right to exploit.

5.2 Review of Environmental Regulations Applicable to Deep Geothermal Energy Developments

Table 5.1 summarises the key European, UK and Scottish environmental protection legislation that could potentially be applicable to on-shore deep geothermal energy developments in Scotland are listed in Tables 5.1 and 5.2. (both after DECC “Environmental legislation applicable to the onshore hydrocarbon industry (England, Scotland and Wales)”, undated). Applicable legislation is discussed in the following sections.

Table 5.1 Key European, UK and Scottish Environmental Legislation (after DECC)

EC Legislation	Associated UK / Scottish Legislation	Main Requirements	Regulator	Comment
EC Directive 2001/42/EC: 'Strategic Environmental Assessment' and EC Directive (85/337/EEC) Environmental Impact Assessment: Assessment of the effects of certain public and private projects on the environment	Environmental Impact Assessment (Scotland) Regulations 1999	Requires certain developments to prepare an Environmental Statement as part of the planning approval process.	Local Authorities	
EC Directive (92/43/EEC) Habitats Directive: Conservation of natural habitats and of wild fauna and flora.	Conservation (Natural Habitats) Regulations 1994	Requires developments to take account of Special Areas of Conservation in their environmental impact assessment. Approvals granted via the above Regulations.	SEPA or Scottish Natural Heritage	
EC Directive (96/82/EC): Control of major accident hazards	Planning (Hazardous Substances) (Scotland) Act 1997 and Planning (Control of Major Accident Hazards) (Scotland) Regulations 2000	Authorisation is required for storage of listed hazardous substances. Requires operators to implement certain management practices and report to the competent authorities.	SEPA & Local Authorities, Scotland	Considered unlikely to apply to geothermal developments.
Water Framework Directive	The Water Environment (Controlled Activities) (Scotland) Regulations 2011	Prevent deterioration and achieve good status for all water bodies, reduce pollution from priority substances in surface waters , reverse significant and sustained upward trends in concentrations of pollutants in groundwater, prevent or limit inputs of pollutants to groundwater.	SEPA	
EC Directive (80/68/EEC) old Groundwater Directive (in force till Dec 2013); and (2006/118/EC) Groundwater Daughter Directive and; EC Directives 2006/118/EC and 2008/105/EC	The Water Environment (Controlled Activities) (Scotland) Regulations 2011	Systems of permits and registrations to control inputs of pollutants to the water environment	SEPA	

EC Legislation	Associated UK / Scottish Legislation	Main Requirements	Regulator	Comment
Directive 2004/35/EC on environmental liability with regard to the prevention and remedying of environmental damage	The Environmental Liability (Scotland) Regulations 2009	To introduce a system of reporting and management of significant releases of pollutants to land and the water environment.	SEPA	
EC Regulation (259/93): Supervision and control of shipments of waste within, into and out of the European Community	Transfrontier Shipment of Waste Regulations 1994	A licence is required to control the transport and disposal of movement and disposal of hazardous waste	SEPA	Considered unlikely to apply to geothermal developments.
EC Regulation (3093/94): Substances that deplete the ozone layer	Environmental Protection (Controls on Substances that Deplete the Ozone Layer) Regulations 1996 Ozone Depleting Substances (Qualifications) Regulations 2006 SI 1510 Fluorinated Greenhouse Gases Regulations 2008 (S.I No 41)	A licence is required for the production, supply, use, trading and emission of certain "controlled substances" that deplete the ozone layer.	DEFRA	Considered unlikely to apply to geothermal developments.
EC Directive 96/61/EC: Integrated pollution prevention and control	The Pollution Prevention and Control (Scotland) Regulations 2000 (as amended)	Control of emissions from industrial premises through requirement to apply Best Available Technology and Permitting	SEPA	
EC Directive 2010/75/EU: Industrial Emissions Directive	Currently proposed to be transposed by means of new Pollution Prevention and Control (Scotland) Regulations, replacing the previous version dating from 2000.	Brings together previous Directives on IPPC, WID, LCP, SED and TiO2 into single text.		Considered unlikely to apply to geothermal developments.
EC Directive 2009/31/EC: Carbon Capture and Storage Directive 2009	UK Energy Act 2008, The Energy Act 2008 (Storage of Carbon Dioxide) (Scotland) Regulations 2011, The Storage of Carbon Dioxide (Licensing etc) (Scotland) Regulations 2011, The Environmental Liability (Scotland) Amendment Regulations 2011	Sets out requirements for carbon capture and geological storage		Considered unlikely to apply to geothermal developments.

Table 5.2 Key UK and Scottish Environmental Legislation (after DECC)

UK Legislation	Main Requirements	Regulator	Comment
Town and Country Planning (Scotland) Act 1997 as amended by the Planning etc (Scotland) Act 2006 Planning and Compensation Act 1991 (as amended) ;and Environment Act 1995 (as amended).	Planning permission is likely to be required for deep geothermal developments.	Local authorities	See Planning Assessment
Pipelines Act 1962; and Pipe-line Works (Environmental Impact Assessment) Regulations 2000	Requires pipelines over 16 km in length to prepare an Environmental Statement as part of the approval process.	DECC	Pipelines for transfer of heat from deep geothermal energy are unlikely to exceed 16km in length so this is unlikely to apply.
Environmental Protection Act 1990, Part II	Most wastes may only be disposed of at a facility operated by the holder of a suitable permit.	SEPA	Unlikely to apply.
Environmental Protection Act 1990, Part III	Statutory nuisance (i.e. non-regulated activities), noise, odour, antisocial behaviour, etc	Local authorities	Likely to be controlled through Planning Conditions
Energy Act 1976; and The Petroleum Act 1998	Consent is required for flaring or venting of hydrocarbon gas. Requires licensees of an onshore field to ensure that petroleum is contained both above and below ground.	DECC	Could potentially apply to certain geothermal developments during construction (drilling).
The Air Quality Standards (Scotland) Regulations 2007. Scottish Statutory Instrument No. 182; The Air Quality Standards (Scotland) Regulations 2010. Air Quality (Scotland) Regulations 2000. Scottish Statutory Instrument No. 97. The Air Quality (Scotland) Amendment Regulations 2002	Set emission limits for certain substances and requires authorities to take action where quality parameters are exceeded. Provides SEPA with reserve powers to improve AQ by LAs where not being achieved.	Local authorities, SEPA	
Control of Pollution Act 1974, Part III; Environmental Protection Act 1990, Part III; and Environment Act 1995, Part V.	Requires local authorities to take action where noise limits are exceeded.	Local authorities	Likely to be controlled through Planning Conditions

UK Legislation	Main Requirements	Regulator	Comment
Environmental Protection Act 1990, Part I; Environmental Protection (Prescribed Processes and Substances) Regulations 1991	Requirement to license certain potentially polluting processes. Industries must demonstrate environmental management through Best Available Technology Not Entailing Excessive Cost (BATNEEC) for IPC	SEPA & Local Authorities	Considered unlikely to apply to geothermal developments. The IPC regime is now superseded by the PPC regime, the 2012 Regulations which also enact the requirements of IED.
The Management of Extractive Waste (Scotland) Regulations 2010		Local Authorities	
Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2000	Application in Scotland under section 36 of the Electricity Act 1989.	The Scottish Ministers	For generation with output >300MW, so unlikely to apply to deep geothermal developments (maximum 10s of MW).
Marine (Scotland) Act 2010 and the Marine and Coastal Access Act 2009 (MCAA)	Marine planning regime for the Scottish marine area.	Marine Scotland	
Radioactive Substances Act 1993	Control of radioactive substances	SEPA	Drilling fluids, geothermal fluids or hydraulic fracturing flow-back fluids may contain Naturally Occurring Radioactive Materials (NORM).
The Management of Extractive Wastes (Scotland) Regulations 2010	Key objective is to ensure that the management of extractive waste is undertaken in a way which prevents, or reduces as far as possible, the risk of adverse effects on the environment and human health.	SEPA	
Water Environment and Water Services (Scotland) Act 2003	The WEWS Act gave Scottish ministers powers to introduce regulatory controls over water activities, in order to protect, improve and promote sustainable use of Scotland's water environment. This includes wetlands, rivers, lochs, transitional waters (estuaries), coastal waters and groundwater.	SEPA	

5.3 Strategic Environmental Assessment (SEA) Directive

The requirement for the assessment of plans, programmes and strategies is set out in EU Directive 2001/42/EC of the European Parliament and of the Council of 27 June 2001 on the assessment of the effects of certain plans and programmes on the environment. This has been transposed into Scots Law through the Environmental Assessment (Scotland) Act 2005.

An SEA is mandatory for plans/programmes which are prepared for agriculture, forestry, fisheries, energy, industry, transport, waste/water management, telecommunications, tourism,

town & country planning or land use and which set the framework for future development consent of projects listed in the EIA Directive or have been determined to require an assessment under the Habitats Directive (see below).

As it stands, it is considered that the legislation already covers the energy sector (including deep geothermal developments) and other land use and planning issues and therefore it is considered that this legislation has been drafted broadly enough so that it does not need to be amended to specifically mention deep geothermal developments.

In addition, the SEA legislation has, in recent years, been widely applied to marine renewable energy plans and strategies and therefore it will also be applicable to plans or strategies relating to any exploitation of offshore deep geothermal developments should these be brought forward.

5.4 Environmental Impact Assessment (EIA) Directive

The EIA Directive (85/337/EEC) on the assessment of the effects of certain public and private projects on the environment came into force in 1985. The directive has been amended three times, in 1997, in 2003 and in 2009. Directive 97/11/EC brought the Directive in line with the UN ECE Espoo Convention on EIA in a Transboundary Context and widened the scope of the EIA Directive by the increasing the number and types of Annex I projects and providing for new screening arrangements, criteria and minimum information requirements for Annex II projects.

Subsequently, Directive 2003/35/EC sought to align the provisions on public participation with the Aarhus Convention on public participation in decision-making and access to justice in environmental matters and Directive 2009/31/EC amended Annexes I and II of the EIA Directive, by adding projects related to the transport, capture and storage of carbon dioxide (CO_2). The initial Directive of 1985 and its three subsequent amendments have been codified by Directive 2011/92/EU of 13 December 2011.

In Scotland, the EIA Directive as amended has been transposed into Scots Law by the Environmental Impact Assessment (Scotland) Regulations 2011 (superseding the original 1999 EIA Regulations). Procedures for applying the EIA process to projects are therefore well established in Scotland and this applies to terrestrial and certain offshore projects.

With regard to application of the Schedules to the Regulations, EIA is mandatory for projects identified in Schedule 1 but is at the discretion of the Planning Authority in relation to Schedule 2 (dependent on the outcome of a Scoping enquiry for the project).

5.4.1 EIA Regulations 2011, Schedule 1

In addition, projects identified in Schedule 1 of the EIA Regulations may be relevant in some circumstances, for example, large scale or more complex projects, as follows:

11. Groundwater abstraction or artificial groundwater recharge schemes where the annual volume of water abstracted or recharged is equivalent to or exceeds 10 million cubic metres.

12. — (1) Works for the transfer of water resources, other than piped drinking water, between river basins where the transfer aims at preventing possible shortages of water and where the amount of water transferred exceeds 100 million cubic metres per year.

(2) In all other cases, works for the transfer of water resources, other than piped drinking water, between river basins where the multi annual average flow of the basin of abstraction exceeds 2,000 million cubic metres per year and where the amount of water transferred exceeds 5% of this flow.

However, it is likely that most deep geothermal projects would be dealt with under on or other of the descriptions given in Schedule 2.

On the basis of the current specific reference to geothermal drilling projects within the EIA Regulations 2011 particularly within Schedule 2, it is considered that this regulatory aspect relating to EIA is adequately covered by current legislation and no recommendations are made for changes to legislation or policy.

However, although technically, if the project is a Schedule 2 project (which it will be) and is less than 0.5 hectare, then it does not require to be Screened for EIA. However, the local authority may decide to consider that the effective footprint is larger than the surface installation (usually based on the red line planning boundary).

Environmental issues would be addressed through planning conditions and CAR where no EIA is undertaken.

5.5 EIA Regulations 2011, Schedule 2

With regard to reference in the Regulations to deep geothermal projects, these were included in the original 1999 regulations and have been retained within the existing EIA regime, under Schedule 2 of the Regulations, as follows:

Description of the Development	Applicable thresholds and criteria
2. Extractive Industry (d) Deep drillings, in particular — (i) Geothermal drilling; (ii) Drilling for the storage of nuclear waste material; (iii) Drilling for water supplies; - with the exception of drillings for investigating the stability of the soil.	(i) in relation to any type of drilling, the area of the works exceeds 1 hectare; or (ii) in relation to geothermal drilling and drilling for the storage of nuclear waste material, the drilling is within 100 metres of any controlled waters.

And also under:

3. Energy industry (a) Industrial installations for the production of electricity, steam and hot water (unless included in Schedule 1);	The area of the development exceeds 0.5 hectare.

The area of 'development' threshold for carrying out an EIA of 0.5 hectare for an energy industry development is currently generally taken as referring to the surface extent, and not the sub-surface extent, of the development.

Geothermal developments could effect a much wider sub-surface extent than the extent of the surface development footprint (compound for drilling and the permanent installation). Indeed, such compounds may be deliberately kept below the threshold to avoid the requirement for an EIA.

Consideration and clarification should be given by Regulators as to whether the EIA threshold for geothermal developments should apply to the surface or sub-surface extent of the development.
The Habitats Directive (and The Birds Directive)

Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora, known as the Habitats Directive, was adopted in 1992. The Directive is the means by which the European Union meets its obligations under the Bern Convention. The main aim of the Habitats Directive is to promote the maintenance of biodiversity by requiring Member States to take measures to maintain or restore natural habitats and wild species listed on the Annexes to the Directive at a favourable conservation status, introducing robust protection for those habitats and species of European importance. The main provisions of the Directive are to:

- Maintain or restore European protected habitats and species listed in the Annexes at a favourable conservation status as defined in Articles 1 and 2;
- Contribute to a coherent European ecological network of protected sites by designating Special Areas of Conservation (SACs) for habitats listed on Annex I and for species listed on Annex II. These measures are also to be applied to Special Protection Areas (SPAs) classified under Article 4 of the Birds Directive 1979; and
- Ensure conservation measures are in place to manage SACs appropriately and to ensure appropriate assessment of plans and projects likely to have a significant effect on the integrity of an SAC.

The Birds Directive has been extensively amended (mainly due to the on-going accession of new member states) and has now been consolidated into Council Directive 2009/147/EC of 30 November 2009 on the conservation of wild birds.

The Habitats Directive is transposed into UK law primarily through The Conservation (Natural Habitats, &c.) Regulations 1994 (as amended). The Regulations apply to land and to territorial waters out to 12 nautical miles from the coast. In Scotland the Habitats Directive is transposed through a combination of the Habitats Regulations 2010 (in relation to reserved matters) and the 1994 Regulations.

In addition, for UK offshore waters (i.e. from 12 nautical miles from the coast out to 200nm or to the limit of the UK Continental Shelf Designated Area), the Habitats Directive is transposed into UK law by the Offshore Marine Conservation (Natural Habitats & c.) Regulations 2007 (as amended).

Again, these regulations have been implemented successfully numerous times with regard to terrestrial and marine projects, and it is considered that they are adequate to cover the likely effects that may arise with regard to on-shore and off-shore deep geothermal developments, on European protected habitats and species.

5.6 Planning (Control of Major-Accident Hazards) (Scotland) Regulations 2000

COMAH primarily applies to chemical, refining and petro-chemical industries, and also to storage or use of dangerous substances, as identified in the Regulations. The regulations require operators to take measures to prevent major accidents, with emphasis on the protection of human health and the environment.

It is considered that the COMAH regulations would generally not apply to geothermal developments, as storage of large quantities of the prescribed dangerous substances is unlikely.

5.7 Water Framework Directive and Groundwater Directives

The Water Framework Directive (the Directive) came into force in 2000 and establishes a legal framework for the protection, improvement and sustainable use of all water bodies in the environment across Europe, covering all rivers, canals, lochs, estuaries, wetlands and coastal waters as well as groundwater. In Scotland the Directive was transposed into Scots Law through the Water Environment and Water Services (Scotland) Act 2003 (the WEWS Act). Amongst other powers the Act provides for new controls over activities such as abstraction, impoundment, engineering, point and diffuse source pollution which directly affect the water environment in the terrestrial environment.

Groundwater is specifically protected by EC Directive 80/68/EEC, the ‘old’ Groundwater Directive which is in force until December 2013, and runs in parallel with EC Directive 2006/118/EC the Groundwater Daughter Directive in the interim.

These controls are implemented by The Water Environment (Controlled Activities) (Scotland) Regulations 2011 and apply to various activities that may affect the water environment including groundwater. It is likely that any deep geothermal project will require authorisation under these Regulations as such developments may involve for example groundwater abstraction, borehole construction and the introduction of hazardous substances or pollutants.

The introduction of heat into the water environment is included in “pollution” as defined in the WEWS Act. In their Supporting Guidance for Groundwater Abstractions – Geothermal Energy (WAT-SG-62), SEPA state that there are environmental impacts in terms of heat addition or loss to groundwater from both systems although there is greater potential for pollution to the water environment and disruption to flow in the water environment from open loop systems. This is because water from open loop systems is removed, potentially changing its chemical composition, and the water may then be discharged in a location different to that from which it was abstracted (including at a different level within an aquifer).

It is considered that this legislation and regime is well established and understood and already considers the implications on controlled waters of deep geothermal projects. Therefore no recommendations for legislation or policy changes are required.

5.8 The Environmental Liability (Scotland) Regulations 2009

The Environmental Liability (Scotland) Regulations 2009 (ELR) place operators of a wide range of activities, including those requiring a requiring a licence under CAR or a PPC permit under obligations to take preventive measures where there is an imminent threat of environmental damage and to take remedial measures where their activities have caused environmental damage. Operators must notify SEPA if they have caused land or water damage or if there is an imminent threat of such damage. Scottish Natural Heritage (SNH) (or Marine Scotland for the marine environment) should be notified in cases where the damage is likely to affect protected species and natural habitats (SEPA, 2012).

Certain activities associated with geothermal energy developments are likely to come within the scope of ELR.

5.9 The Pollution Prevention and Control (Scotland) Regulations 2012

The PPC Regulations are not considered to be relevant to geothermal energy developments.

5.10 The Air Quality Standards (Scotland) Regulations 2007. Scottish Statutory Instrument No. 182 and The Air Quality Standards (Scotland) Regulations 2010

Geothermal energy developments generally do not have significant emissions and are unlikely to contravene the air quality standard regulations.

5.11 The Management of Extractive Waste (Scotland) Regulations 2010

SEPA’s Regulatory Guidance on coal bed methane and shale gas (November 2012) states that the production of “flow-back” fluid (recovered fracturing fluids) from hydraulic fracturing is a mining waste activity. It is considered that the regulations would also apply to deep geothermal developments if similar techniques were used to enhance or engineer the geothermal reservoir.

SEPA state that these activities will be controlled through planning permission for the site through an agreed waste management plan. Operators will need to have a waste management

plan in place, and be able to demonstrate to planning authorities how they will store and dispose of wastes safely without causing pollution to the environment. This may include a requirement to have a CAR authorisation for any discharge of any pollutants to the water environment.

SEPA also state that waste from “prospecting” may not be a mining waste activity and the storage of waste at the site of production, prior to onward transfer for recovery or disposal is automatically covered by a Paragraph 41 Waste Management Licence Exemption, which does not need to be registered.

5.12 Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2000

These regulations relate to any application in Scotland under section 36 of the Electricity Act 1989 for consent to construct, extend or operate a generating station (also any application under section 37 of the Act for consent to install or keep installed an electric line above ground).

Section 36 of the Electricity Act 1989 refers to all non-nuclear generating stations with an output in excess of 300 megawatts. It is unlikely that a deep geothermal project would generate enough power to be subject to a Section 36 consent, but this legislation is included for completeness.

Overall, the EIA approach included in these Regulations conforms to the requirements of the EIA Directive. It is therefore considered that the existing environmental impact assessment regime is currently adequate to deal with deep geothermal projects in Scotland.

5.13 Marine (Scotland) Act 2010

The Marine (Scotland) Act 2010 and the Marine and Coastal Access Act 2009 (MCAA) have introduced a marine planning regime for the UK marine area. The Scottish Government has responsibility for marine planning within both STW (0 -12nm), and devolved powers for marine planning matters within the Scottish REZ (12 – 200nm).

The Marine (Scotland) Act 2010 and MCAA provide for the creation of Marine Protection Areas (MPAs), which will be afforded particular protection on account of their nature conservation, historic or research and development value.

At such time as any deep geothermal projects in the marine environment are brought forward, these marine planning issues and any MPAs will be taken into consideration in the consenting process.

5.14 Radioactive Substances Act 1993

The Radioactive Substances Act 1993 (‘RSA93’) controls of radioactive substances, including Naturally Occurring Radioactive Materials (NORM).

NORM Industrial Activities are cited in the Radioactive Substances Act 1993 Amendment (Scotland) Regulations 2011 and specifically include production of oil and gas; activities related to coal mine de-watering plants; and water treatment associated with provision of drinking water

and remediation of past work activities. Geothermal energy is not currently listed as a NORM Industrial Activity, however, there is the potential for drilling fluids, geothermal fluids or hydraulic fracturing flow-back fluids may contain NORM.

It is recommended that geothermal energy should be listed as a NORM Industrial Activity in a future revision of the Regulations. In the interim, good practice would dictate that developers should adhere to the Regulations as if geothermal energy was included.

5.15 Consenting of Onshore Deep Geothermal Energy Developments

5.15.1 The Water Environment (Controlled Activities) (Scotland) Regulations 2011

SEPA has produced specific Supporting Guidance for Groundwater Abstractions – Geothermal Energy (Ref. WAT-SG-62, v3.0, February 2013).

Geothermal energy is included as a controlled activity (specified in column 1 of Part 1 of Schedule 3), authorised under the Regulations if it is carried out in accordance with the rules of general application ("general binding rules") specified for that activity in column 2 of that Schedule.

- GBR3 applies to boreholes constructed for the purpose of supplying geothermal energy by means of a closed loop system.
- GBR17 applies to open loop geothermal systems (i.e. abstraction and subsequent reinjection of groundwater for the purposes of extracting geothermal energy from the abstracted water).

Table 5.3 General Binding Rules applicable to Deep Geothermal Energy (CAR Schedule 3)

Column 1 Activity	Rules
3. The construction or extension of any well, borehole or other works by which water may be abstracted, or the installation or modification of any machinery or apparatus by which additional quantities of water may be abstracted, if such works are – a) not intended for the purpose of abstraction b) intended for the abstraction of less than 10 m^3 of water in anyone day; c) intended for the abstraction of less than 150 m^3 of water in any period of one year, and the purpose of the abstraction is either – i. to test for the yield of the borehole or well or the hydraulic properties of the aquifer; or ii. to sample the water quality; d) intended to dewater one or more excavations at – iii. construction site for roads, buildings, pipelines, or other built developments; or	(a) Subject to paragraphs (b) and (c), the construction of the well or borehole must be such as to avoid the entry of pollutants or water of a different chemical composition into the body of groundwater (b) drilling fluids may be introduced into the well or borehole if necessary to facilitate the drilling of the well or borehole provided this does not result in pollution of the water environment; (c) potable water may be introduced into the well or borehole to test the hydraulic properties of the aquifer; and (d) when the well or borehole is not being used for abstraction, it must be back filled or sealed to the extent necessary to avoid loss of groundwater from any aquifer

i. a site at which the maintenance of such developments is being undertaken; e) intended for the purpose of undertaking activity 17.	
17. The abstraction and subsequent return of groundwater for the purpose of extracting geothermal energy from the abstracted water.	(a) The abstracted water must be returned to the same geological formation from which it was abstracted; (b) any volume of water may be abstracted but the volume of water abstracted and not returned must not exceed $10m^3$ per day; (c) the chemical composition of the abstracted water must not be altered prior to its return to the geological formation; (d) there must be a means of demonstrating that the net abstraction is not more than $10m^3$ in any one day; and (e) water leakage must be kept to a minimum by ensuring that all pipe work, storage tanks and other equipment associated with the abstraction and use of the water are maintained in a good state of repair.

Regulation 10 gives SEPA the power to impose authorise additional measures for controlled activities authorised under Regulation 6 General Binding Rules if it considers that additional measures are necessary to protect the water environment. This allows SEPA to request any further information required to inform the determination process for an authorisation application, including such other information specified in Annex IV of the EIA Directive considered relevant to determination of the application.

Further guidance is provided in the following SEPA documents

- The Water Environment (Controlled Activities) (Scotland) Regulations 2011, A Practical Guide
- Supporting Guidance (WAT – SG – 62) Groundwater Abstractions – Geothermal Energy

In relation to GBR17 (abstraction for geothermal energy and subsequent return of groundwater) - new rules clarify that any volume of water may be abstracted but that the volume of water abstracted and not returned must not exceed $10m^3$ per day.

The guidance sets out the levels of licence complexity based on increasing abstraction rates and also provides some information on how to consider the environmental impacts of geothermal energy systems in order to prevent pollution of the water environment and operate in an effective way.

5.15.2 CAR Complex Licence for Borehole Construction

From 1st April 2013 a CAR complex licence is required to allow deep boreholes (>200m) to be constructed and also conditions any maintenance or monitoring required to ensure that the borehole does not result in contamination of groundwater. Once the borehole has been decommissioned to SEPA's satisfaction, the licence can be surrendered.

Further information is available in SEPA's Regulatory Method (WAT-RM-11) Licensing Groundwater Abstractions including Dewatering, v4, February 2013.

5.15.3 Other Relevant SEPA Regulatory Guidance

SEPA's Regulatory Guidance on coal bed methane and shale gas (November 2012) covers several activities that are may be applicable to particular deep geothermal energy developments, including the following:

Injection of fluid (including fluid for hydraulic fracturing), if applicable

Authorisation for injection is required from SEPA. Monitoring of groundwater will be a condition of authorisation.

Abstraction of water for injection purposes, if applicable

Where water is abstracted from the water environment to be used for example during fracturing, an application for authorisation must be submitted to SEPA, unless the abstraction falls within the scope of Activities 2 or 4 of Schedule 3 of CAR16.

Where the water intended for fracturing is supplied by a water provider who abstracts that water from the water environment and the abstraction is not authorised via a GBR, the supplier must hold an appropriate SEPA authorisation.

Abstraction of flow-back fluid, if applicable

Where flow-back fluid (recovered fracturing fluids) and/or groundwater are abstracted from the borehole, an application for authorisation should be submitted to SEPA, unless the activity falls under Activities 2 or 4 of Schedule 3 of CAR and the abstraction meets all the General Binding Rules for that activity.

Management of abstracted fluids, if applicable

Discharges that are likely to have an impact on the water environment require prior authorisation under CAR. Re-injection of flow-back fluid is not capable of authorisation under CAR; flow-back water is classed as extractive waste and is regulated by the local authority through planning controls and the Extractive Waste Regulations.

5.15.4 SEPA's Remit

As noted in Regulatory Guidance on coal bed methane and shale gas (November 2012), SEPA do not have a remit to regulate the fracturing of rock, and as such do not issue licences for fracturing. SEPA's role is to control the impacts on the water environment.

Similarly, SEPA do not currently have a specific direct remit to licence extraction of geothermal heat however they do regulate the Water Environment (including groundwater) and heat is considered a potential groundwater pollutant. They could use their powers under CAR to protect an abstraction from heat and, potentially, loss of heat (to an adjacent geothermal development).

5.16 Issues Around Stimulation for Development Geothermal Resources

In the future, Enhanced Geothermal Systems (EGS) may be used for extracting heat for electricity generation (and heat production) from deep petrothermal sources. Developing EGS requires the use of hydraulic fracturing to artificially increase the mass permeability of the source zone such that injected fluid can flow readily from the injection well(s) to the extraction / production well(s). EGS is still an emerging technology and commercial application of such systems in Scotland may still be some way off.

In 2012 there was much public concern was expressed in the UK regarding hydraulic fracturing ('fracking') for shale gas extraction. This followed suspension of hydraulic fracturing operations in May 2011, pending the investigation of two seismic tremors experienced near Preese Hall, Lancashire. Part of the public concern stems from reported groundwater pollution and gas emissions incidents during hydraulic fracturing / shale gas extraction in the USA.

Following expert review, DECC has now implemented a requirement for seismic risk assessment to be undertaken to assess the risks from hydraulic fracturing for shale gas extraction, with approval required prior to commencement of operations.

There are some marked distinctions between hydraulic fracturing for EGS and that undertaken for shale gas extraction, as described below, and it is important that these are conveyed to the public to ensure that public and political opinion of all geothermal energy remains positive. Clear communication of the issues involved and the distinctions between hydraulic fracturing.

The differences (and similarities) in the requirements have been summarised in a fact sheet prepared by the European Geothermal Energy Council (EGEC, 2013).

Hydraulic fracturing may induce seismic events but the scale of these will vary dependent on the situation. For EGS, hydraulic fracturing is only likely to be undertaken for projects for extracting heat for electricity generation (and heat production) from deep petrothermal sources and not for projects that only produce heat. Because the required temperatures for electricity production are only available at significant depth, any required hydraulic fracturing is only likely to be undertaken at depths of greater than 4km in crystalline rocks. This is at greater than the depths from which shale gas is extracted, which is typically from depths of 2 to 3km.

The crystalline rock used as a source of geothermal heat does not contain organic material and therefore will not release methane and other organic gases. This is also well below the depth of potable groundwater supplies (it is anticipated that there will be no groundwater at these depths) so there is no risk of potable groundwater contamination directly from hydraulic fracturing.

Hydraulic fracturing has already been used successfully used in the Highlands of Scotland to increase the yield from public water supply boreholes, including at relatively shallow depth

(<100m) (Cobbing and Ó Dochartaigh, 2007) and their has been little public concern over induced seismicity prior to the negative publicity surrounding shale gas extraction.

It is recommended that as part of operators seeking consent under a licensing process, a seismic risk assessment would be carried out for all deep geothermal projects. It is anticipated that this will follow a similar form to those now required for hydraulic fracturing for shale gas, comprising:

- Conduct a prior review of information on seismic risks and the existence of faults in the area;
- Submit to DECC a hydraulic fracturing plan showing how any seismic risks are to be addressed;
- Carry out seismic monitoring before, during and after the hydraulic fracturing; and
- Implement a “traffic light” system which will be used to identify unusual seismic activity requiring reassessment, or halting, of operations.

5.17 Consenting for Off-Shore Geothermal

A study on the “Consenting, EIA and HRA Guidance for Marine Renewable Energy Developments in Scotland”, Parts 1 to 4 (EMEC and Xodus Aurora, April 2010) undertaken for the Scottish Government describes the streamlined consenting process for marine renewable energy developments and introduces a single point of access for consents and licensing. It sets out the applicable legislation and regulatory bodies. While the guidance is aimed at Marine Renewables (wave and tidal energy), it is considered that the proposed approach it could equally be applied to the development of offshore geothermal developments. Consideration should therefore be given to inclusion of offshore deep geothermal development within this guidance and consenting process.

5.18 Discussion and Conclusions

Environmental legislation relating to assessment and consenting issues in relation to deep geothermal projects has been reviewed. These legislative regimes are mainly based on various European Directives and associated UK and / or Scottish legislation or regulations. These are generally well established in Scotland.

In particular, activities relating to deep geothermal projects are specially identified in Schedule 2 of the EIA Regulations 2011 and may be covered by other environmental consenting processes depending on their scale and whether they would be located on-shore or off-shore.

It is noted however that under the existing Regulations, EIA for deep geothermal development is only likely to be required if the surface footprint of the development is greater than 0.5 hectares, regardless of the sub-surface extent of the geothermal developments. A planning authority could,

however, potentially take the view that the whole (sub-surface) area effected by the geothermal energy development and require an EIA, as the effected area is likely to be larger than the red line boundary. There is therefore potential for inconsistency in application of the Regulations for EIA.

Existing environmental permitting legislation has been reviewed in relation to deep geothermal projects. These legislative regimes are based on the European Water Framework Directive, enacting legislation for which is well established in Scotland. In particular, activities relating to geothermal projects are specially identified in Schedule 3 of the Water Environment (Controlled Activities) (Scotland) Regulations 2011, with further discussion provided in relevant SEPA guidance notes.

It is noted that regardless of the capacity of an (open loop) geothermal energy development, in terms of volume of extracted groundwater, as long as the volume of water abstracted was no more than $10m^3$ than the volume re-injected (as would normally be the case) then the development would be covered by GBR17 and SEPA would not currently need to be consulted (other than a as a Statutory Consultee in any planning permission required). The CAR Complex Licence required for all boreholes >200m deep from 1st April 2013 only applies to the construction of the borehole in relation to prevention of contamination between aquifers etc and would not necessarily consider the function of the geothermal development itself. This is notwithstanding the fact that heat is defined under legislation as a potential pollutant. Clarification of these issues could be presented by SEPA in revised Regulatory Guidance for geothermal energy.

Concern was expressed during the stakeholder workshop over potential standards for re-injection of groundwater following heat extraction, potentially to Drinking Water Standards (DWSs) and / or Environmental Quality Standards (EQSs) which could be overly onerous and may inhibit development of geothermal resources, particularly those in areas of poor or marginal groundwater quality such as many former mining areas.

Hydraulic fracturing is unlikely to be required for the development of geothermal resources to extract heat only. Hydraulic fracturing may, in the future, be required to develop deep engineered/enhanced geothermal systems (EGS) for electricity and heat production from deeper resources. Hydraulic fracturing for unconventional gas development is covered by Petroleum Exploration and Development Licensing (PEDL) and following review of procedures in 2012, additional seismic risk assessment is now required by DECC in the consenting process.

Although, the existing framework of legislation could control geothermal development in Scotland, some changes to the legislation should be considered.

5.19 Recommendations

The following recommendations are made in relation to the environmental regulatory regime for deep geothermal energy.

- A review of current EIA regulations in relation to considering the surface or sub-surface extent of potential geothermal developments should be considered by the Scottish Government and advice issued accordingly.
- Specific reference to “deep geothermal” or “geothermal” when drafting future environmental legislation would provide clarity and assist potential developers of geothermal energy projects and should be considered by the Scottish Government.
- Clear guidance on the application of relevant environmental legislation would be beneficial for potential developers of geothermal energy projects and production of a specific Regulatory Guidance document for deep geothermal development, similar to the Regulatory Guidance for coal bed methane and shale gas by SEPA, is recommended.
- In particular, it is recommended that SEPA should consider and produce revised guidance on whether the application of GBR’s is appropriate in all cases and what constitutes groundwater heating or cooling pollution in relation to geothermal developments.
- It is considered that the approach outlined in a recent Scottish Government study for the streamlined consenting process for Marine Renewables (wave and tidal) could equally be applied to the development of offshore geothermal developments and inclusion of offshore deep geothermal development within this guidance and consenting process should therefore be considered for potential future offshore geothermal developments.
- Water quality could actually be improved by geothermal heat extraction treating extracted water before discharge or re-injection, including removing iron from ferrous-rich mine waters. The Coal Authority has a pilot scheme for pumping, treating and extracting heat from mine water discharge at Dawden in Co. Durham. It is recommended that the results of this study are considered for future mine water geothermal projects.
- It is recommended that geothermal energy should be listed as a NORM Industrial Activity in a future revision of the Regulations. In the interim, good practice would dictate that developers should adhere to the Regulations as if geothermal energy was included.
- Any resource licensing system developed for deep geothermal energy should include the potential for hydraulic fracturing potentially required for enhanced geothermal systems (EGS) for electricity and heat production from deep petrothermal resources (see Section 3 - The Ownership of Geothermal Resources in Scotland). It is recommended that operators seeking consent under a new licensing process, would be required to carry out a seismic risk assessment for all deep geothermal projects. It is anticipated that this will follow a similar form to those now required by DECC for consenting of hydraulic fracturing for shale gas developments.

Planning Regulations, Policies, Plans and Guidance for Deep Geothermal Energy Developments

6 Planning Regulations, Policies, Plans and Guidance for Deep Geothermal Energy Developments

6.1 Introduction

The Scottish Government wishes to promote geothermal energy as a low-carbon energy source and encourage its commercial development.

As part of this study, a review of the existing legislation, regulations, policy and guidance has been undertaken. The aim of the review is to identify potential barriers within the planning system, and opportunities for positive interventions.

The mapping of potential geothermal resources, in conjunction with other sources of information (including the results of ongoing heat mapping across Scottish planning authority areas), will inform spatial planning by identifying areas of both heat demand and potential geothermal energy resources. In addition, some areas with suitable geothermal heat resources at significant depth (4 to 5km) will also be suitable for relatively small-scale electricity generation (typically <10MW) as well as heat production. Identifying demand and supply will allow development plan land allocation to be considered.

A review of the following has been undertaken to identify potential barriers to geothermal energy within the existing planning regime, including:

- planning legislation (acts and regulations);
- planning national planning policies (National Planning Framework (NPF) 2 (2009) and Scottish Planning Policy (SPP) (2010));
- Scottish Government Circulars, Planning Advice Notes (PANs) and online renewables planning advice; and
- Relevant local authority development plans and policies, and emerging development plans and policies, (in the geographic areas identified as having the most developable geothermal energy resources)

Based on the review, potential changes (or ‘interventions’) have been identified and recommended for planning legislation, national policy, guidance and advice, and local authority development plans and policies.

6.2 Review of The Planning System with Respect to Geothermal Energy

6.2.1 Summary of the Planning Documents Reviewed

The documents reviewed are summarised in Table 6.1. The full planning document review is summarised in Appendix B.

Table 6.1 - Existing Planning Documents Reviewed

Level	Document
Acts	The Town and Country Planning Act (Scotland) 1997
	Planning etc. (Scotland) Act 2006
	Climate Change (Scotland) Act 2009
Regulations	The Town and Country Planning (Development Planning) (Scotland) Regulations 2008
	The Town and Country Planning (Development Management Procedure) (Scotland) Regulations 2008
	The Town and Country Planning (Hierarchy of Development) (Scotland) Regulations 2009
Guidance	Circulars (contain guidance on policy implementation)
Online Renewables Planning Advice	Deep Geothermal (March 2012)
National	Scottish Planning Policy (SPP) (2010) prepared by Scottish Government, sets out policy on a range of issues.
	National Planning Framework 2 (2009) prepared by Scottish Government, sets out a spatial strategy for Scotland's development NPF3 to be prepared by Scottish Government (from autumn 2012).
Regional	Structure Plans (Being Replaced)
Local	Local Plans (Being Replaced)
Strategic Development Plan Areas	Strategic Development Plans (SDPs) currently being prepared by strategic development planning authorities
Local	Local Development Plans (LDPs) currently being prepared by local development plan planning authorities
Local	Supplementary Guidance

Table 6.2 Existing planning legislation in relation to geothermal energy

Level	Document	Comment
Acts	The Town and Country Planning Act (Scotland) 1997	No specific reference to energy / geothermal energy.
	Planning etc. (Scotland) Act 2006	Geothermal energy is not referenced within the Act. Energy is referenced wrt development plans.
	Climate Change (Scotland) Act 2009	Addresses energy efficiency, but not specifically geothermal energy.
Regulations	The Town and Country Planning (Development Planning) (Scotland) Regulations 2008	Energy and geothermal energy are not referenced within the Regulations.
	The Town and Country Planning (Development Management Procedure) (Scotland) Regulations 2008	Energy and geothermal energy are not referenced within the Regulations.
	The Town and Country Planning (Hierarchy of Development) (Scotland) Regulations 2009	Energy and geothermal energy are not referenced within the Regulations.

Table 6.2 summarises the existing planning legislation in relation to geothermal energy.

6.3 Summary of the Review of Existing Planning Legislation (Acts and Regulations)

Table 6.3 Recommended amendments to planning documents

Document	Potential / Recommended Amendments
The Town and Country Planning (Scotland) Act 1997	None
Planning etc. (Scotland) Act 2006	A potential change to the Act includes specific reference to geothermal energy. Recommended action includes the application of a change to the Act, through a provision inserted into the Act, which relates specifically to geothermal energy and the requirement for Strategic Development Planning Authorities and Local Development Planning Authorities to acknowledge the potential for geothermal energy development, when preparing their Plans and considering how development in their area should and could occur
Climate Change (Scotland) Act 2009	None
The Town and Country Planning (Development Planning) (Scotland) Regulations 2008	None
The Town and Country Planning (Development Management Procedure) (Scotland) Regulations 2008	None
The Town and Country Planning (General Permitted Development) (Scotland) Order 1992	Consider amending to specifically allow specific small-scale geothermal heat energy within permitted development.
Circulars	Consider amending Circular 2/2011 to specifically allow specific small-scale geothermal heat energy within permitted development.
Online Renewables Planning – Deep Geothermal (March 2012)	Recommended review and amendment (see comments in text).

Document	Potential / Recommended Amendments
Scottish Planning Policy (SPP) (2010)	A recommended change to SPP is specific reference to geothermal energy as a renewable energy technology to be supported by local authorities to respond to energy generation requirements and climate change targets. It is recommended that Scottish Planning Policy (SPP) is amended and updated to include specific reference to geothermal energy. Reference should be included within paragraphs 182-195, which relates to renewable energy.
National Planning Framework	It is recommended that National Planning Framework (NPF) is amended by means of the review of NPF3. Geothermal energy should be highlighted within NPF3 as a source of energy generation which can contribute to national energy use from renewable sources targets.
Structure Plans, Strategic Development Plans and Local Plans	It is recommended that specific reference to geothermal energy is addressed through the cyclical review process or in current emerging plans.

6.3.1 Acts and Regulations

It is considered that the Acts and Regulations have been drafted in a broad-enough manner to incorporate geothermal energy without amendment.

6.3.2 The Hierarchy Regulations 2009

The Town and Country Planning (Hierarchy of Development) (Scotland) Regulations 2009, the 'Hierarchy Regulations', classify developments into a hierarchy of three categories:

- National Developments;
- Major Developments; and
- Local Developments.

Geothermal energy has not, to date, been classified as a National Developments under the National Planning Framework (NPF), see below.

In addition, geothermal energy developments are unlikely to be classified as 'Major Developments':

Class 1 - Schedule 1 Developments – those that require an EIA. This is unlikely to apply to the vast majority of geothermal energy developments (see Section 5.0 – The Environmental Regulatory Regime review). Geothermal development sites in England have reportedly deliberately been kept below 0.5Ha to avoid the requirement for an EIA.

Class 4 - The minimum threshold for electricity generation is 20MW. This is unlikely to apply to geothermal energy developments, particularly in the near future) as generation capacities are likely to be lower. The current largest planned scheme in south-west England at United Downs at Redruth in Cornwall has a projected power output of 10MW. SKM have predicted the power output of a conceptual geothermal demonstrator project in north-east Scotland to be <1MW.

Class 9 – Includes all other developments with a site area >2Ha or structure footprint of >5,000m2. This is unlikely to apply to the vast majority of geothermal energy developments as the surface footprint is relatively small.

Other Classes – are unlikely to apply to geothermal energy developments

It is therefore considered that, in the main, individual geothermal energy developments will therefore be classified as Local Developments under the regulations. It is considered that, dependent on uptake, geothermal energy may be become of national significance as an energy source in the future.

From the point of view of encouraging geothermal energy developments, being classified as Local Developments has the advantage that they would not be subject to the more onerous requirements in the planning process that apply to National Development, such as the Proposal of Application Notice (PAN) procedure.

A key challenge is including and promoting geothermal energy, classified as 'Local Developments', at national planning policy level.

6.4 Review of Existing Planning Guidance and Advice

6.4.1 Circulars

The Circular relating to renewable energy for non-domestic microgeneration (Circular 2/2011) defines permitted development in relation to ground source heat pump (GSHP) systems but deeper geothermal energy is not covered. The permitted development rights are only for the buried or immersed pipework, meaning that the heat exchanger unit must be sited within an existing structure.

Strictly ground source heat is derived from warming of the near-surface by solar energy, which only extends a few metres into the ground. Where boreholes are used to collect or dissipate heat in a GSHP system they often extend to depths of >100m (to usually <200m) and there is a

transition into shallow geothermal energy. As these systems are generally closed loop systems the impact is considered to be low.

It is also apparent that small-scale geothermal heat energy could be incorporated in a similar way with buried wellheads and pipework and all above ground plant (most likely incorporating a heat pump) within buildings.

The Scottish Government may wish to consider further amending the Town and Country Planning (General Permitted Development) (Scotland) Order 1992 and amend Circular 2/2011 to specifically allow small-scale geothermal heat energy within permitted development in a similar manner to GSHP systems.

6.4.2 Advice

The Scottish Government provides a range of advice on different subjects and in different forms, including Guides, Letters from the Chief Planner, Design Guidance, Planning Advice Notes, online renewables planning advice (which replaced PAN45).

6.4.3 Online Renewables Planning Advice on Deep Geothermal Energy

The online renewables planning advice is primarily aimed at providing advice to planning authorities. It suggests areas of focus, opportunities within planning processes for deep geothermal to be considered, it identifies typical planning considerations, provides technical information and links to useful resources. A concern expressed by planning officers attending the project stakeholder workshop was a lack of knowledge and experience in geothermal energy. It is important therefore for the advice to be comprehensive and accurate.

This has been reviewed as part of this study and is considered to provide a useful basis. It is recommended that it should be amended to provide more specific advice, to reflect the better understanding of available resource now available and differentiate clearly between shallower heat-only schemes (the likely future majority of schemes) and deeper power and heat schemes.

The following are suggested changes that could be incorporated in a review of the online advice:

‘Snapshot’

- It is recommended that the following is highlighted in the document following the review:
- The terminology should be updated to reflect the main types of geothermal energy resource as ‘hydrothermal’ (from groundwater) and ‘petrothermal’ (from hot rock). The majority of resources developed will be hydrothermal;
- Consider redefining definition of ‘deep’ geothermal;
- The clear differences, including the scale differences within, including between heat-only and heat and power schemes;

- That there is much greater potential for development of heat-only schemes, that the majority of schemes will be heat-only and therefore development of these is likely to be more widespread;
- That the development of heat and power schemes in Scotland is some way off;
- That the surface development for geothermal energy is relatively small; and

Suggested areas of focus for planning authorities:

- Planning authorities should review the available geothermal resources (this should be made available to planning authorities as GIS layers following the publication of this study);
- Planning authorities should review the heat mapping for their area to identify areas of heat demand or identify areas / locations of known heat demand (if heat mapping is not yet available for their area);
- Planning authorities should then consider land use opportunities and constraints within areas identified as having both geothermal resource and heat demand;
- Planning authorities should consider opportunities for developing heat networks based on geothermal and in conjunction with other sources of heat and / or power; and
- The Scottish Government should provide more detailed advice on assessing deep geothermal planning applications and on key consultees.

Opportunities within planning processes for Planning Authorities

- Monitoring and Main Issues Report (MIR) – the advice should be revised in cognisance of the resources information resulting from this study;
- Spatial planning
    - the focus should be on matching heat resource, demand and land use opportunities;
    - Consider revising terminology from ‘heat mains’ to the broader term ‘heat networks’;
    - Note potential for integration with other sources of heat and / or power, e.g. CHP plants;
- Draft development plan policy – consider mentioning heat networks;
- Information for planning applications;
    - Further advice should be provided on developing supporting guidance notes as there is a generally low level of knowledge within planning authorities; and
    - Note that it is very unlikely that the generating capacity of future geothermal power plants will be greater than 20MW

- Pre-application – currently there is no requirement for pre-planning consultation but it should be encouraged;
- Determination of planning applications – no comments.

Technical information for deep geothermal

- Re-define ‘deep’ geothermal, and thereby also shallow geothermal, as being 200m depth;
- The geothermal terminology should be updated to reflect the main types of geothermal energy resource as ‘hydrothermal’ (from groundwater) and ‘petrothermal’ (from hot rock). The majority of resources developed will be hydrothermal;
- Recognise the gradation with depth from GSHP-type developments, into schemes with geothermal source and a heat pump (heat only), direct geothermal heat source only (heat only) and then deeper heat and power type developments;
- Note that Enhanced Geothermal Systems in very deep petrothermal sources is in its infancy of development. Suitable heat resources at depth have not been sufficiently defined to date in Scotland to locate such schemes. This may change in the future with investment in exploration of the resource;
- Suitable locations – refer to the potential resources mapping being undertaken as part of this study;
- Physical works – provide information on typical surface site extents and surface infrastructure required during exploration and during operation and decommissioning;

Typical planning considerations in determining planning applications for deep geothermal

- Note that drilling for the deepest schemes (>1km) are likely to be 24 hours per day but that these schemes will be relatively infrequent;
- Note that emissions from modern geothermal plants (including steam) are likely to be very low. Geothermal plants are very quiet and should not produce odours;
- Once constructed, access to the geothermal site will generally be for maintenance purposes only with few deliveries required;
- Change terminology from ‘waterway’ to the ‘water environment’, and both surface and groundwater needs to be considered;
- Note that stimulation (hydraulic fracturing) is very unlikely to be used in the vast majority of geothermal developments and only for the deepest EGS projects in the future. The risk of induced seismic activity does exist and would need to be adequately addressed, including through risk assessment, by the developer. Note the depth of stimulation and therefore the risks are relatively low for geothermal projects; and

- Generally geothermal schemes will have a relatively low landscape and visual impact and some items of plant can be located below ground level.

References

- Update the references to refer to this study and recent work by SKM for Scottish Enterprise (SKM, 2012b).

6.5 National Planning Framework (NPF)

National Planning Framework 2 highlights the key challenges and issues relating to energy and renewable energy. However, the Framework does not make specific reference to geothermal energy and it has not, to date, been classified as a National Development(s) under the NPF.

Part 3 of NPF2 highlights Key Challenges for Scotland, including Energy, specifically highlighting:

- Section 25 “Concerns about the implications for future energy prices and long-term security of supply. Addressing these challenges will demand profound changes in the way we produce, distribute and use energy over the coming decades.”;
- Section 26 “committing to deriving 20% of the energy it uses from renewable sources by 2020. The Scottish Government supports this objective and has in place its own, higher target for electricity generated from renewable sources. It also wants to see continued improvements in energy efficiency; the development of technologies which derive clean energy from fossil fuels; the harnessing of renewable sources of heat; and decentralised energy production, including local heat and power schemes and micro-generation.”

Geothermal energy is well suited to meeting these key challenges, particularly as:

- a renewable source of heat;
- provides decentralised energy production;
- can be readily incorporated in local heat and power schemes; and
- micro-generation

Part 5 of NPF2 (Infrastructure) discusses Renewable Energy. Section 144 states the requirement to derive a higher proportion of Scotland’s energy requirements for heating from renewable sources. Geothermal energy is a source of renewable heat.

Section 145 states the Government’s commitment to a growing renewable energy mix and specifically mentions offshore wind, wave, and tidal energy, and biomass. It does not specifically mention geothermal energy. It also states the Government’s commitment to establishing Scotland as a leading location for the development of renewable energy technology. If promoted, there are opportunities for geothermal energy as part of the renewable energy mix, particularly from low temperature resources to be a key part of this technology.

Section 146 deals with the growing and various contributions from renewable energy technologies and notes that a specific strategy for the development of marine renewable energy is being prepared. It is recommended that the Scottish Government should develop a similar strategy for the development of geothermal renewable energy.

Section 147 notes that some renewable energy technologies have a strong spatial dimension, i.e. they require a large area. Geothermal energy in particular has a small surface spatial dimension which reduces its spatial impact.

Section 149 notes the valuable contribution that small-scale renewable energy projects can make, the fact they can play a vital role in supporting the sustainable development of remote rural and island communities in particular and could cumulatively make a significant contribution to the development of a more decentralised pattern of energy generation. Geothermal energy is well suited to decentralised small-scale renewable energy provision.

Section 151 in relation to Baseload Power Stations notes the variable output of some renewable sources of energy. Geothermal power production is almost unique amongst renewable technologies in being able to provide baseload.

Section 163 in relation to Heat recognises the potential to derive more heat for domestic, business and industrial purposes from sources such as ground, water and air source heat pumps and the commitment to building a commercially viable and diverse heat industry. Geothermal energy is another and greater source for heat suited to heating multiple dwellings or business premises, or industrial use.

Section 164 regarding Decentralised Production including encouraging community and household heat and power generation, the decentralisation of generation capacity and the development of local heat networks. Section 165 states that Planning authorities have an important role in facilitating more decentralised patterns of energy generation and supply and also that they should take account of the potential for developing heat networks when preparing development plans and considering major development proposals. Geothermal energy could play a key role in heat (and possibly power) generation and is ideal for supplying baseload heat to heat networks.

As discussed above, individual geothermal energy developments are likely to be classified as Local Developments due to their scale. It is considered that, dependent on uptake, geothermal energy may be become of national significance as an energy source in the future but it may not be appropriate to classify it as such at present.

Geothermal energy fits very well with the Scottish Government’s renewable energy aspirations and commitments, particularly in relation to sources of renewable heat and de-centralised energy generation. Heat-only geothermal developments are ideal for co-locating in or near residential, commercial or industrial development as they are unobtrusive and have a compact surface footprint In the future, geothermal energy may also be able to contribute to electricity production, and the siting of these is less critical as electricity can be readily transmitted but it would be advantageous to also have a use for the heat output.

The NPF3 main issues report is currently under consultation. It is recommended that geothermal energy is specifically included in NPF3.

A key challenge is including and promoting geothermal energy, classified as 'Local Developments', at national planning policy level.

6.6 Scottish Planning Policy (SPP) (2010)

The consolidated Scottish Planning Policy (SPP) is intended by the Scottish Government to provide a concise, clear and focused statement of national planning policy. SPP is currently being reviewed by the Scottish Government.

Renewable energy is referenced in detail with the current SPP, however, it does not currently make specific reference to geothermal energy.

An outcome of the project stakeholder workshop for this study (including representation from planning officers from various planning authorities) was that current planning applications can only be dealt with under existing planning policies and to deal with primary planning impacts in terms of policy context requires strategic level support - there is currently a perceived lack of policy coverage.

It is considered that changes to planning policy in relation to promoting geothermal energy would give greater planning certainty. This would assist in de-risking potential geothermal energy projects and therefore encourage investment.

It is therefore recommended that the Scottish Government should consider specifically including geothermal energy at national planning policy level in the updated SPP currently under consultation. This could include a statement on a presumption favour of geothermal developments.

6.7 Structure Plans, Strategic Development Plans and Local Plans

Structure Plans set out long term visions and policies for the development of land within planning authority areas. They provide a broad framework for Local Plans, which contain more detailed and site specific policies. The two plans together form the Development Plan. For the city regions of Aberdeen, Dundee, Edinburgh and Glasgow, Structure Plans are being replaced under the new planning system by Strategic Development Plans (SDPs).

The Structure Plans and / or emerging SDPs for Aberdeenshire, Clackmannanshire, Fife, Glasgow and West Lothian were reviewed as these areas are among those with geothermal energy resource potential. None of the Structure Plans or SDPs refers specifically to geothermal energy, with the exception of the Mid-Fife Local Plan.

The Mid-Fife Local Plan Policy I1 provides guidance in relation to Renewable Energy including the following references to geothermal energy:

"Proposals to abstract geothermal energy from groundwater and other sources will be supported throughout Fife provided that the drilling, engineering and abstraction operations do not:

f. cause unacceptable impacts on the built and natural environment, and residential and other sensitive properties; and

g. do not cause pollution of groundwater."

The Mid-Fife Local Plan is a good example of a supportive local planning policy. It is recommended that similar policies on geothermal energy are adopted by other planning authorities in the next review of their Structure Plans, Strategic Development Plans and Local Plans.

The Glasgow City Plan 2 energy policy (Policy ENV15), which primarily relates to new buildings requires the following:

- ".....consider the installation options available for a low and/or zero carbon decentralised energy source, including consideration of a shared resource with a neighbouring development.";
- "All new developments should consider the installation of micro-generating equipment (see Definition) for the small scale production of heat (less than 45 kilowatt thermal capacity) and/or electricity (less than 50 kilowatt electrical capacity) from zero or low carbon source technologies, particularly at a domestic level."; and

The Glasgow City Plan 2 energy policy, although it does not specifically make reference to geothermal energy, is useful in that it requires the building developer to consider on site microgeneration using zero and low carbon equipment.

6.8 Geothermal, District Heating and Planning

To achieve renewable heat energy targets and the desired uptake, it may be necessary to require new-build developers to install district heating systems. It may be possible to encourage or incentivise developers to include geothermal energy as the, or part of, the heat source.

6.9 Identification of Required Changes to Planning Documents and Recommendation for Actions

Following the review of the planning documents in relation to geothermal energy, Table 6.3 summarises recommended amendments.

6.10 Conclusions

In relation to national planning policy and achieving the Scottish Government's ambitious targets for renewable/low carbon and decentralised sources of energy, geothermal energy is a good source of renewable and low carbon heat. In the future it may also be a source of power. If promoted correctly, there are opportunities for geothermal energy as part of the renewable energy mix, particularly from low temperature resources to be a key part of this technology.

It is considered that a strategy for the development of geothermal energy is required to focus efforts into key areas.

Geothermal energy is has the following advantages as a source of energy:

- It has a small surface spatial dimension which reduces its spatial impact;
- It is well suited to decentralised small-scale renewable energy provision;
- it is a source for heat suited to heating multiple dwellings or business premises, or industrial use.
- It could play a key role in heat (and possibly power) generation and is ideal for supplying baseload heat to heat networks.
- Geothermal power production is almost unique amongst renewable technologies in being able to provide baseload.

Current planning applications can only be dealt with under existing planning policies and to deal with primary planning impacts in terms of policy context requires strategic level support. There is currently a perceived lack of policy coverage. The Scottish Government could consider changes to planning policy in relation to promoting geothermal energy to give greater planning certainty. This would assist in de-risking and therefore encourage investment.

A key challenge is including and promoting geothermal energy, classified as 'Local Developments', at national planning policy level.

Individual geothermal energy developments are likely be classified as Local Developments under the Hierarchy Regulations. It is considered that, dependent on uptake, geothermal energy may be become of national significance as an energy source in the future.

The Mid-Fife Local Plan is a good example of a supportive local planning policy for geothermal energy. It is recommended that similar policies on geothermal energy are adopted by other planning authorities in their emerging Strategic Development Plans and Local Development Plans.

There is a need to communicate positive messages to the public regarding deep geothermal energy, including that heat generated is used locally (as opposed to generating electricity to be used elsewhere) and it is a relative cheap, low-carbon and reliable source of heat energy.

6.11 Recommendations (Policy Options)

The following are the key recommendations:

- The NPF3 main issues report is currently under consultation and it is recommended that geothermal energy is specifically included in NPF3;
- It is recommended that the Scottish Government should develop a specific strategy for the development of geothermal energy (similar to the strategy for the development of marine renewable energy);
- It is recommended that the Scottish Government should consider specifically including geothermal energy at national planning policy level in the revised SPP. This could include a statement on a presumption favour of geothermal developments;
- To achieve renewable heat energy targets and the desired uptake, it may be necessary to require new-build developers to install district heating systems. It may be possible to encourage or incentivise developers to include geothermal energy as the, or part of, the heat source;
- Planning Authorities require the expertise to assess geothermal energy applications. The current perceived lack of clarity and specific advice could potentially lead to delay in determination of applications. Supplementary specific planning guidance (SPG) for deep geothermal energy should be developed;
- It is recommended online renewables planning advice on deep geothermal is revised to provide more specific advice, reflect the current understanding of available resource, and differentiate clearly between shallower heat-only schemes (the likely future majority of schemes) and deeper power and heat schemes;
- Circular 2/2011 relates to renewable energy for non-domestic microgeneration. It is recommended that the Scottish Government may wish to consider amending Circular 2/2011 to specifically allow small-scale geothermal heat energy within permitted development in a similar manner to GSHP systems;
- It is recommended that policies on geothermal energy are adopted by planning authorities in the next review of their Strategic Development Plans and Local Development Plans;
- Deep geothermal (>200m depth) should be included in current and future reviews of Local Development Plans as the review cycle dictates. Planning Authorities require information on the spatial distribution of both deep geothermal resources and heat demand, so that they can be linked;
- Table 6.3 summarises the recommended amendments to Planning documents.

Costs, Financing and Benefits Assessment for Deep Geothermal Energy Developments

7 Costs, Financing and Benefits Assessment for Deep Geothermal Energy Developments

7.1 Introduction

In considering how best to take forward the commercialisation of geothermal energy in Scotland, it is important to identify the potential benefits that geothermal energy could deliver to Scotland, but also make an assessment of the likely costs, consider the potential risks, and review the requirement for financial support mechanisms.

These have been considered with options for unlocking the possible range of potential geothermal developments in Scotland.

7.2 The Benefits of Developing the Deep Geothermal Energy Potential

There are many direct and indirect benefits to utilising geothermal energy including the following:

(a) As a potential source of energy, geothermal energy -

- Is a low-carbon source of energy and could help Scotland reduce carbon emissions and build a sustainable low carbon economy in order to meet the legislative requirements for emissions reductions.
- Could increase the use of renewable heat to help exceed the targets set out in the 2020 Routemap for Renewable Energy in Scotland.
- Could help to exceed the targets for renewable electricity production.
- Could become a viable alternative source of energy, improving local and national energy security and reducing reliance on external sources of energy.
- Holds the potential for developing relatively small-scale energy supplies close to demand, reducing transmission losses.
- Has low visual impacts and the majority of the surface plant can be accommodated below ground level if necessary to reduce visual impact further.
- Is relatively quiet with no visual emissions meaning that it can be sited un-obtrusively in mixed-use or even residential areas.
- Has a low impact on the water environment, with water extracted and re-injected in a cycle.

(b) Specifically as a potential source of heat, geothermal energy -

- Can provide heat directly to homes, businesses and industry via a heat network.
- Does not suffer from conversion inefficiencies.
- In central Scotland, mine water resources may be present close to areas of fuel poverty, a key area that the Scottish Government wishes to address.

(c) As a potential source of power, geothermal energy -

- Can almost uniquely provide base-load from a renewable resource.
- Is always and consistently available - excluding time for maintenance and repair - but with more than one plant this could be scheduled and coordinated.
- Is switchable to the load (the output can be adjusted up or down) within the operation parameters of the generating plant.
- Its conversion can be switched on and off.
- Co-produces heat which can be utilised.

(d) The key indirect potential benefits of developing the geothermal energy sector in Scotland include:

- Regeneration of brownfield sites, including in former mining and industrial areas.
- Provision skilled employment opportunities, with potential cross-over and skills transfer from the oil and gas, manufacturing and traditional energy-generation sectors.
- It could push Scotland towards the forefront in the technology required for exploiting deep geothermal resources, particularly in areas previously considered as marginal or even not viable.
- Presents the opportunity to provide environmental benefits, for instance treating poor quality abstracted groundwater before re-injection.

7.3 Skills Transfer and The Existing Scottish Skills Base

In their report for Scottish Enterprise, SKM carried out a high-level review of the potential for development of a Scottish supply chain from existing industry skills, notably the oil and gas sector (SKM, 2012b).

These included scientific, engineering (oil & gas), design engineering, construction, operations and non-technical. SKM also highlighted that geothermal energy technology is unique, with unique risks, and recommended that a further more detailed study should be carried out.

To the author's knowledge, there are currently no Scottish-based specialist deep geothermal energy development companies. It is acknowledged that there are a number of Scottish-based companies, or companies with a presence in Scotland, operating in the GSHP market. It is considered that some of these companies could up-scale in the future to meet a demand for geothermal heat production schemes, many of which would utilise heat pump technology.

To date the international geothermal industry has concentrated on developing easily accessible high-temperature resources. It is considered that there is a significant opportunity for Scotland to

develop unique skills in developing low temperature geothermal resources, and then exporting these skills internationally, to countries with similar types of geothermal resource.

Costs should reduce over time with increasing resource knowledge, technical experience and competition in the industry. Conversely costs may increase if there is increased international demand for geothermal skills and specialist equipment.

7.4 Assessment of Typical Costs for Deep Geothermal Energy

Geothermal energy developments cover a very wide range of scales with orders of magnitude difference in outputs, from relatively shallow single boreholes which also utilise heat pumps (typical outputs from 0.02kWth to 0.05kWth per metre of installed borehole) to potentially 10's MWth and 10's MWe for a very deep petrothermal system (say 5km).

The range of costs for exploring, appraising, developing, operating and decommissioning the various scales of development is correspondingly also very wide.

Cost data on the capital and operating (CAPEX and OPEX) costs for geothermal energy has been taken from various sources.

7.4.1 The Quality of Available Cost Data

The current availability of cost data relating to geothermal energy in Scotland and / or the wider UK is low. This is for a number of reasons:

- Geothermal developments are not currently common in Scotland or the UK.
- There is only one existing operating deep geothermal development in the UK; part of the Southampton district heating scheme which has been operational since the 1980s and was largely publically funded.
- True actual outturn costs (both CAPEX and OPEX) are generally commercially sensitive and are not widely published. This is particularly true where there has been significant overspend due to the high risks involved.
- Globally, figures are more widely available for traditional high-temperature power schemes, as opposed to a range of lower temperature heat only and moderate temperature heat and power schemes as envisaged in Scotland.

Detailed costs and risks analysis is not currently possible based on the available data, however, estimation of costs has been made to illustrate likely magnitude of CAPEX costs and cost per installed Megawatt (MW).

Caution needs to be exercised when reviewing the benefits of geothermal energy in other countries, including capacity factors and levelised costs for power production, as the vast majority of developments across the globe have been developed for electricity generation using high temperature resources (>150°C) that are relatively close to the surface. Costs increase

significantly per MWe generated for lower temperatures resources and with increasing depth to resources. Binary technology can be used to generate electricity theoretically down to geothermal fluid temperatures of <100°C. However, the efficiency of such systems decreases significantly with reducing temperatures.

Scotland does not have any high temperature resources close to the surface. Such resources may exist at depths of circa 5km (or more) but this has not been proven to date. High temperature resources may be at a depth beyond the current limit of commercially available technology.

There is also a lack of suitable data available for shallower resources, i.e. those at less than 200m depth.

7.4.2 Review of Costs and Estimated Costs

For this study, AECOM has undertaken a high-level review of available costs for geothermal energy projects to provide an understanding of the scale and range of costs involved.

Costs and estimated costs were gathered from the following sources:

- Internet search for published costs associated the geothermal energy globally.
- Review of costs provided for various deep geothermal schemes in England from presentations at the EGS Energy 2012 UK Geothermal Symposium, London (15 October 2012).
- Review of estimated costs in SKM's 2012 report for Scottish Enterprise.
- AECOM internal enquiries for projects in Asia and New Zealand.

7.4.3 Costs for Heat-Only Projects

Table 7.1 summarises reported available costs data for heat-only projects and these are illustrated in Figure 7.1.

Table 7.1 Published and reported CAPEX costs for geothermal energy developments: heat-only projects

Location	Company	Size	Nr. of production wells	Depth of production wells	Approx. Cost / Estimated Cost	Description &Source
Shiremoor, North Tyneside, UK	Cluff Geothermal Ltd	3-5 MWth	2	2.0km	£TBC	Proposed heat-only. Presentation by Cluff Geothermal Ltd at the EGS Energy UK Geothermal Symposium, 15 October 2012.
Manchester, UK	GT Energy	9.5 MWth	2	3.2km	£TBC	Proposed heat-only. Presentation by GT Energy Ltd at the EGS Energy UK Geothermal Symposium, 15 October 2012.
Szentlorinc, Hungary	PannErgy	3 MWth	1	1.8km	£2.8m	Hungary's largest operational geothermal heating facility from a very complex geology. PannErgy May 2012, Geothermal Energy.
Madrid, Spain	Petratherm Limited	8 MWth	Unknown	2.2 – 2.8km	£7.9m	At least 75°C; Flow rate of 200 cubic metres per hour. Petratherm, 2008, "Geo-Madrid District Heating Project - Well Re-entry Yields 30% Cost Savings" http://www.petratherm.com.au/projects/mainland-spain
Cheshire	Unknown	11.5	Unknown	3.4	£18m	Conceptual. Hydrothermal direct heat. From SKM 2012a.
Wessex	Unknown	10	Unknown	3.0	£16m	Conceptual. Hydrothermal direct heat. From SKM 2012a.
Lough Neagh	Unknown	5	Unknown	2	£10m	Conceptual. Hydrothermal direct heat. From SKM 2012a.
Newcastle	Unknown	4	Unknown	1.5	£8m	Conceptual. Hydrothermal heat pump. From SKM 2012a.
Herleen, NL	Unknown	0.7 MWth heating / 1.0 MWth cooling	5	0.8	£16m	http://ec.europa.eu/environment/ecoap/about-eco-innovation/good-practices/netherlands/328_en.htm. The costs are thought to include a district heating system and back-up gas boilers for peak demand.

Figure 7.1 Heat-Only Projects (a) CAPEX Cost versus Thermal Production Capacity and versus Depth, and (b) Thermal Production Capacity versus Depth

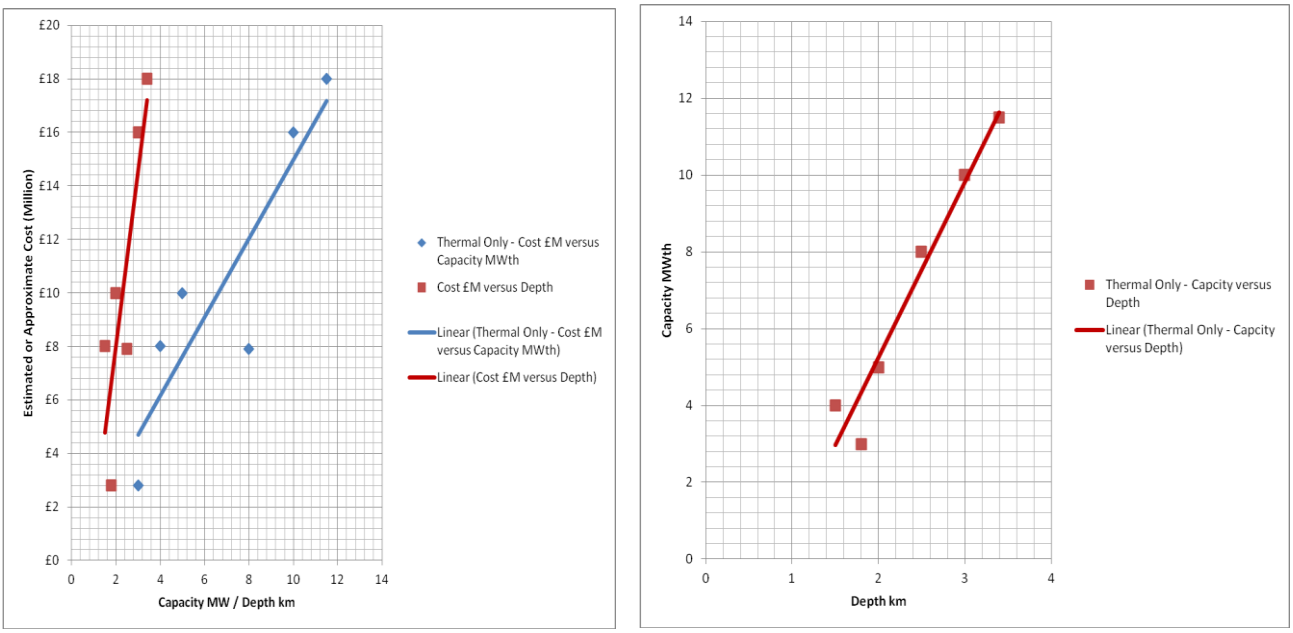


Figure 7.1 demonstrates that based on the available reported and estimated CAPEX costs for heat-only developments, there is an apparent relationship of both increasing costs and increasing capacity with increasing depth, as would be expected. Relative capacity appears to increase at a slightly greater rate than costs with depth. Relative capacity appears to significantly increase with depth. It appears therefore that increasing the depth of the geothermal well increases the efficiency for this type of project.

Caution is required in drawing too firm conclusions from this due to the potential unreliability of the data from a limited number of examples, and they should not be used for assessing likely CAPEX costs due to the high number of variables involved. They are, however, considered to provide a preliminary indication of the general trends.

The costs for the Herleen mine water project of circa £16m are thought to include a district heating system and back-up gas boilers for peak demand. The system serves approximately 200 houses, shops, offices, a library and a supermarket. All the buildings contain heating and cooling systems designed to run on energy from the mine water. Calculations estimate that the concept offers a 55% CO_2 reduction.

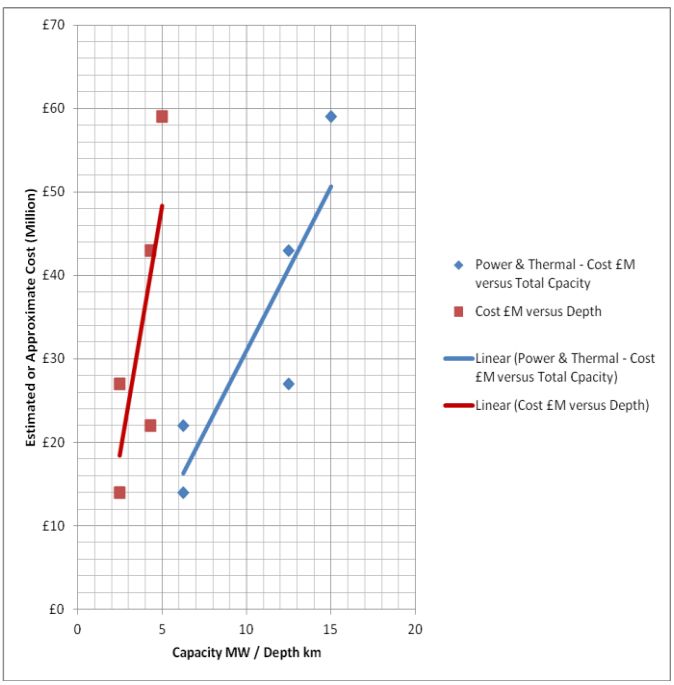
7.4.4 Costs for Combined Electricity Generation and Heat Projects (Petro and Hydrothermal Resources)

Table 7.2 summarises the available costs data for combined electricity generation and heat projects. These are illustrated in Figures 7.2 and 7.3, for hydrothermal and petrothermal resources respectively.

Table 7.2 Published and reported costs for geothermal energy developments: Electricity Generation and Heat projects (Petrothermal and Hydrothermal)

Location	Company	Size	Nr. of production wells	Depth of production wells	Approx. Cost / Estimated Cost	Description &Source
NE Scotland (TBC)	SKM/SE	0.7 MWe	4	5km	£50.5m	Proposed conceptual deep geothermal demonstrator project for Scottish Enterprise using a petrothermal source with stimulation, 'EGS'. Estimated additional £27.5 million OPEX costs (SKM, 2012a).
United Downs, Redruth, Cornwall, UK	Geothermal Engineering Ltd	7 MWe 50 MWth	3	4.5km	£50m	Proposed power & heat, petrothermal (EGS) scheme. Geothermal Engineering Ltd at the EGS Energy UK Geothermal Symposium, 15 October 2012
The Eden Project, Cornwall, UK	EGS Energy Ltd / The Eden Project	3-4 MWe	2	4.0km	£TBC	Proposed power & heat, petrothermal (EGS). Presentation by EGS Energy Ltd at the EGS Energy UK Geothermal Symposium, 15 October 2012.
Wessex	Unknown	0.75 MWe 5.5 MWth	Unknown	2.5	£14m	Conceptual. Hydrothermal heat and power. From SKM 2012a.
Wessex	Unknown	1.5 MWe 11 MWth	Unknown	2.5	£27m	Conceptual. Hydrothermal heat and power. From SKM 2012a.
Cheshire	Unknown	0.75 MWe 5.5 MWth	Unknown	4.3	£22m	Conceptual. Hydrothermal heat and power. From SKM 2012a.
Cheshire	Unknown	1.5 MWe 11 MWth	Unknown	4.3	£43m	Conceptual. Hydrothermal heat and power. From SKM 2012a.
Lake District	Unknown	5 MWe 10 MWth	Unknown	5.0	£59m	Conceptual. Petrothermal heat and power. From SKM 2012a.

Figure 7.2 Combined Electricity Generation and Heat Production Projects for Hydrothermal and Petrothermal Sources (a) CAPEX Cost versus Total Production Capacity and versus Depth, and (b) Total Production Capacity versus Depth.



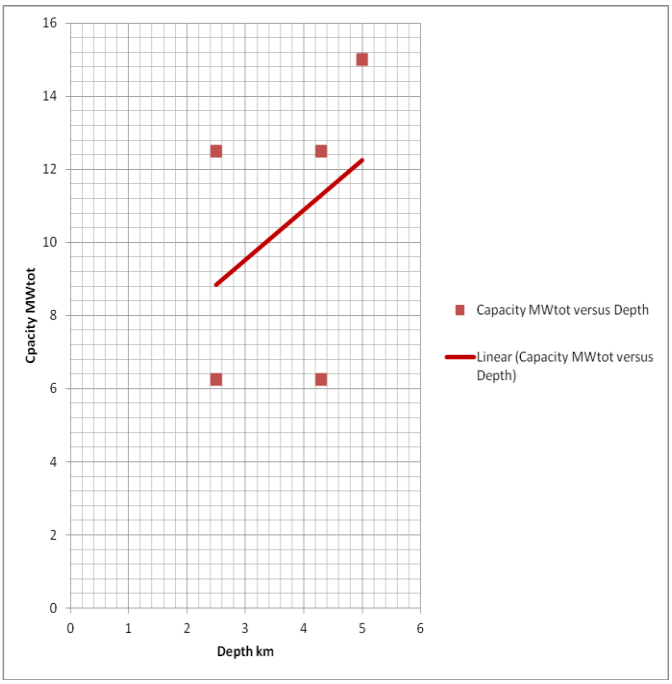


Figure 7.2 demonstrates that based on the available reported and estimated CAPEX costs for combined electricity generation and heat-producing developments, there is an apparent relationship of both increasing costs and increasing capacity with increasing depth, as would be expected. Costs appear to increase at a slightly greater rate than relative capacity with depth.

Relative capacity appears to increase linearly with depth. It appears therefore that increasing the depth of the geothermal well increases the capacity but also disproportionately increases the costs for this type of project. This may be due to the effect of the rate of drilling costs increasing with depth.

The proposed conceptual deep geothermal demonstrator project for Scottish Enterprise has been excluded from Figure 7.2 as no output for heat is provided and it is non-commercial project. The proposed United Downs project has also been excluded from Figure 7.2 as the output for heat of circa 50MW significantly skews the graph. The proposed development at the Eden Project has been excluded as estimated costs are not available. This means that only one proposed combined electricity generation and heat-producing development for a petrothermal source is represented on the graph; the proposed Lake District scheme.

Caution is required in drawing too firm conclusions from this due to the potential unreliability of the data from a limited number of examples, and they should not be used for assessing likely CAPEX costs due to the high number of variables involved (note the scattered nature of the data). They are, however, considered to provide an indication of the general trends.

7.4.5 Costs from the German FiT Review for Geothermal Energy

A recent review carried out in Germany examined the costs of six power producing projects, which were all <5MWe. The drilling costs were in the range of £17m to 24m per project. Development and plant costs for the six projects ranged from £19m to 27m.

7.4.6 Typical Costs from New Zealand and South East Asia

AECOM's operations in New Zealand have been responsible for installation of over 4500MWe over 30 years. The costs provide a contrast for comparison; these costs are from a mature market in south east Asia and New Zealand, with a plethora of high temperature resources available. Table 7.3 indicates costs for typical

Table 7.3 Published and reported costs for geothermal energy power developments in New Zealand and South-East Asia from AECOM

Company	Size	Nr. of production wells	Depth of production wells	Approx. Cost / Estimated Cost	Description &Source
AECOM	40 MWe	14	2.0 - 2.5 km	£41.1m	Typical example only, high temperature (steam).
AECOM	60 MWe	18	2.0 - 2.5 km	£50.4m	Typical example only, high temperature (steam).
AECOM	10 MWe	-	-	£26m	Typical example only, 'low' temperature 100% brine plant. Note 'low' is classified as circa 230°C in NZ.
AECOM	60 MWe	-	-	£109m	Typical example only, 'low' temperature 100% brine plant. Note 'low' is classified as circa 230°C in NZ.

These figures clearly demonstrate the significant difference in typical costs for developing geothermal between what is classified regionally as high temperature (300°C) and geothermal resources that are defined in this high-temperature context as 'low' temperature (230°C).

7.4.7 Summary of Costs for Installed Capacity for Geothermal Energy

From the information gathered, Table 7.4 summarises the estimated CAPEX costs per MW for installed capacity for deep geothermal energy.

Table 7.4 – Estimated Costs per MW for installed capacity for deep geothermal energy

Scenario	Typical Cost Installed Capacity
Heat only (UK / Europe), <1km	Data unavailable
Heat only (UK / Europe), >1km	£0.93M to £2.00M/MW
Power & heat – hydrothermal (UK / Europe)	£4.12M to 28.67M/MW
Power & heat – petrothermal (UK / Europe)	£7.14M to 28.67M/MW
Power & heat - German FiT review	£7.2M to £10.2M/MW
Power – Steam (New Zealand)	£0.8M to £1.0M/MW
Power – Brine (New Zealand)	£1.8M to £2.6M/MW
Onshore wind (UK) – for comparison(1)	£1.4M/MW
Offshore wind (UK) – for comparison(1)	£3.0M/MW

(1) based on figures on figures from BWEA (now RenewablesUK) in the Scottish Enterprise, Energy Market Forecast Costs for The Wind Market, 2009 to 2014, published in 2010.

It can be seen that relative to other available and established renewables in the UK, deep geothermal energy is currently relatively expensive per installed MW for combined electricity and heat developments, but that the costs of heat-only developments may be similar to the current costs of onshore wind.

It is anticipated that costs would decrease and with market development and maturity and as the resources are proved.

7.4.8 Estimated Levelised Costs of Geothermal Energy

The European Geothermal Energy Council (EGEC) published a policy paper in June 2013 regarding financing geothermal energy which contains the a summary of levelised costs of geothermal energy and predicts costs for 2030, on a Europe-wide basis (see Table 7.5).

Table 7.5 – Levelised Costs for Geothermal Energy (quoted in EGEC, 2013)

Type	Source / Use	Levelised Costs Range 2012 (€/kWh)	Average Levelised Costs 2012 (€/kWh)	Predicted Average Levelised Costs 2030 (€/kWh)
Electricity Generation	Electricity Conventional – high T	0.05 to 0.09	0.07	0.03
	Low temperature and small high T plants	0.10 to 0.20	0.15	0.07
	Enhanced Geothermal Systems	0.20 to 0.30	0.25	0.07
Heat Production	Geothermal HP	0.05 to 0.30	0.08	0.05
	Geothermal DH	0.02 to 0.20	0.06	0.04
	Geothermal direct uses	0.04 to 0.10	0.05	0.04

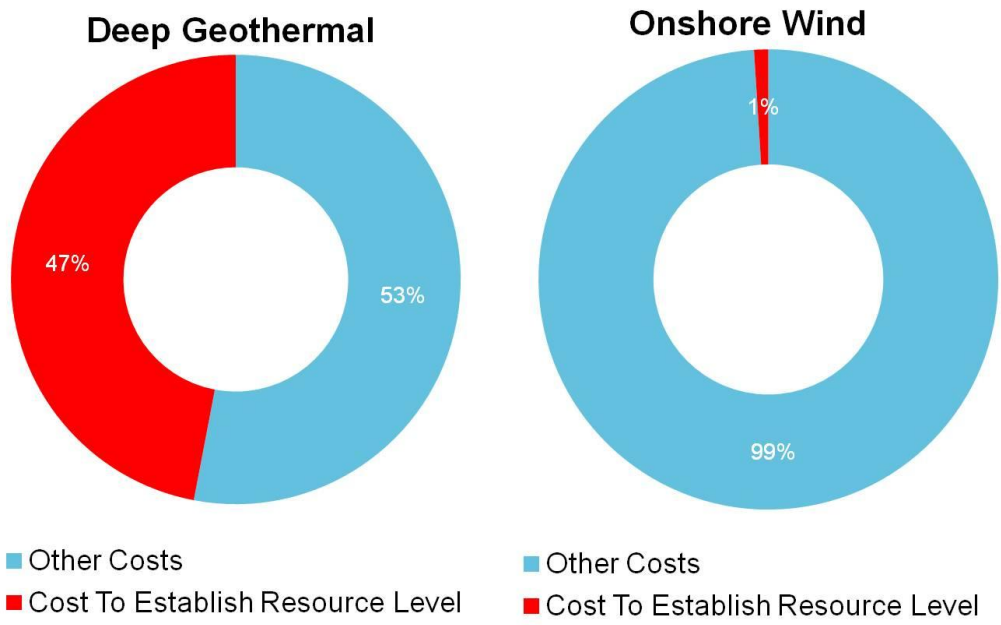
7.4.9 Drilling Costs versus Total Project Costs for Geothermal Energy

For deep geothermal energy, the cost of drilling exploratory and production wells is high and is also a high percentage of the capital costs for the project. In addition, the size of the available resource is not known until the initial exploratory well is drilled.

The typical cost split for deep geothermal from the German FiT review is illustrated in Figure 7.4 and, for comparison, the cost split for onshore wind is also shown. It can be seen that the costs for proving the resource are much higher for deep geothermal than for wind relative to other costs.

This makes geothermal appear to be a relatively high risk for investors and can make project funding difficult without grant support.

Figure 7.4 - Typical Percentage Cost Split for Resource Establishment versus Other Costs



7.4.10 Operation and Maintenance Costs and Decommissioning costs

It has not been possible to establish independent operation and maintenance (OPEX) and decommissioning costs for deep geothermal projects as suitable data is not readily available.

SKM estimate (based on knowledge and previous experience) that the OPEX for

For decommissioning it is anticipated that various scenarios exist, including:

- Declining production (depleted resource) to below economic levels and plant at the end of its operational life – decommission and remove plant, grout production wells over full depth.

- Non-depleted or only partially depleted resource to operating at economic levels but plant at the end of its operational life – decommission and replace plant, renovate production wells.

For the existing Southampton geothermal well, comprising a single 1800m deep extraction well (with discharge to surface water), the turbine-driven pump operated from the mid 1980s to 2006 (approximately 20 years). The pump is currently being replaced with grant assistance from DECC and is scheduled to be operational again in 2013.

7.4.11 Predicted Capacity Factors and Base-load from Geothermal Energy

To be regarded as providing base-load, energy sources generally need to have a capacity factor of 70% or greater.

Capacity factors for geothermal energy power production are often quoted at rates of 85% or more, and these figures are used in finance models, including when seeking investment in proposed projects, and determining revenue from projects.

In October 2011, Bloomberg New Energy Finance (BNEF) released a report on Geothermal Plant Performance and comparing the performance of 71 geothermal fields globally (source http://www.thinkgeoenergy.com). The purpose of the study was to determine the actual level of capacity factors. For a global average, BNEF quotes a capacity factor of 73% which is below the figures often quoted and used in financial models.

Of potential concern in a Scottish context is that the majority of the geothermal resources included in the study are high temperature resources and it was reported by BNEF that statistically capacity factors were found to decrease at a rate of around 1% per decrease in temperature of 10°C. It was also noted that there was evidence of decreasing productivity of geothermal fields over time in older plants, possibly due to depletion of the resource and ageing infrastructure.

If capacity factors are actually lower than initially estimated it may lead to issues with fulfilling power supply agreements and decrease revenues, which could lead to difficulties meeting servicing debt and interest payments.

7.5 Financing Assessment

7.5.1 Risk / Benefit Imbalance

There is considered to be a current a risk / benefit imbalance for determining the level of support required for deep geothermal projects. Revenue support levels are set at the limit of what is financeable at the point of financial close. However, the revenue level can only be projected when resource is fully understood. For the deeper geothermal projects in the Scotland (or the UK) the resource is poorly understood. It is therefore difficult to set an appropriate revenue level.

For geothermal energy, as for oil and gas, there is a high level of risk in early phase of resource evaluation. However, in the oil and gas industry the cost levels are driven by well understood and competitive contracting rates.

A key challenge is how to encourage or incentivise early stage exploration of deep geothermal resources. Without this early stage exploration the deep geothermal energy industry will not develop in Scotland.

7.5.2 Current Support Mechanisms for Geothermal Energy

Power Generation

In the UK, electrical power production from deep geothermal energy is currently supported at a level of 2.0 ROCs (Renewable Obligation Certificates), this is approximately equivalent to 13.5p/kW. It was announced by DECC in October 2012 that they propose to reduce this to 1.8 ROCs in 2017.

For comparison, the following are the ROCs available for other forms of renewable energy:

- 1 ROCs [circa 8p/kWh]
    - Onshore Wind (reducing to 0.9 in 2017)
- 2 ROCs [circa 13.5p/kWh]
    - Geothermal (reducing to 1.8 in 2017)
    - Offshore Wind (reducing to 1.8 in 2017)
    - PV (reducing to 1.5 in 2017)
- 3 ROCs [circa 19p/kWh]
    - Tidal (increasing to 5 in 2017)
- 5 ROCs [circa 29p/kWh]
    - Wave (change to5 in 2017)

Of these renewable energy technologies, only geothermal is capable of supplying base-load.

Heat Production

The current RHI (Renewable Heat Incentive) is set at a level of 3p/kWth for >100kWth capacity.

7.5.3 Comparison with Support Mechanisms in Other Countries

Other European nations with establishing deep geothermal industries have the following levels of support available for power generation:

- Germany FiT (all sizes):
    - Current ~20p/kWh (Up from ~12.5p in 2007)
    - Bonus of 3.5p for using EGS
- Belgium, Slovakia, Croatia, Czech:
    - 13.5-17.5p/kWh

It is evident that the levels of support available in Germany, where similar geothermal resources are available to the UK, have stimulated significant development of the geothermal industry.

7.5.4 Current Proposed Support Mechanisms

Power Generation

It was announced by DECC in October 2012 that this would reduce from 2.0 in 2012 to 1.8 by 2017. Levels of proposed future FiT's have not currently been announced.

Heat Production

DECC are currently consulting on a proposed a RHI (Renewable Heat Incentive) level of support of 5p/kWh for 'deep' geothermal (categorised by DECC as >500m depth).

7.5.5 Effectiveness of Support Mechanisms

ROC Levels

From the project stakeholder workshop it was generally considered that ROCs are a good support mechanism for development of the deep geothermal (power and heat) industry if they are pitched at right level.

It is questioned whether geothermal, as a developing market, would realistically be able to take advantage of the current UK level of support of 2 ROCs, as it is likely that much activity will take place post-2013 (with support reducing to 1.8 ROCs in 2017). A ROC level of 4 to 5 was considered to be more reasonable and realistic for deep geothermal as an emerging technology, similar to wave / tidal, but that has the potential to provide base-load.

Another concern for potential developers of geothermal energy in Scotland is that ROCs should be compatible with other countries, particularly European countries (including Germany), as projects are competing in the international market for investment.

Proposed Renewable Heat Incentive

It is considered that the RHI level of 5p/kWh currently proposed by DECC could make the business case for deep geothermal heat developments (>500m depth) sustainable.

Exploration Risk Insurance

Schemes in other countries, generally backed by exploration risk insurance, can also receive grant-funding without affecting the receipt of support mechanisms, making them more attractive to investors. Additionally, the industry and definition of resources is significantly more advanced reducing the risks further for investors.

7.5.6 Future Support Mechanisms Structure

The UK Government announced in its Electricity Market Reform (EMR) white paper in July 2012 that it was replacing the existing Renewable Obligation Certificate (ROC) system for subsidising low carbon electricity sources.

From 2017/18 new projects will instead use feed in tariffs (FiT's), similar to other countries but combined with a concept called Contracts for Difference (CfD) . Under FiT's, electricity producers will be paid for each MWh of renewable power that they produce (the 'strike price'), the rates for which are yet to be decided, with an adjustment to ensure the producer does not lose out from changes in the actual price of electricity. The UK government predicts this will save 4% from consumer bills by 2030.

In essence, therefore, the ongoing legislation development related to renewables support can and will have an uncertain and significant impact on how cost/benefits are estimated at any given time for geothermal power schemes, which at this stage in the development of the technology depend to a large extent on government support mechanisms to become a commercially viable option.

7.5.7 Interventions used in Germany

In Germany, the MAP (Marktanreizprogramm) provides Federal and State-backed grants and reduced-rate loans to lower the early-stage risks of deep geothermal projects. It is focused on heat but is also available for power. The aim of the MAP is to stimulate the use of renewable heat and lay the foundations for more private investment.

Also available in most countries with a developing geothermal industry is state-backed exploration (drilling) risk insurance. This is insurance against failure to prove the resource. In Germany, exploration risk insurance is available from the federal / state development bank (KfW Bankengruppe) but is also backed by the German insurance industry.

7.6 Proposed Interventions to Encourage Increased Activity in Scotland

Revenue support has a track record of success in UK in developing renewable technologies. It is possible that with appropriate revenue support mechanisms in place that the market will lead to

the development of the deep geothermal industry in Scotland but this may be at a rate that is slower than desirable. There is a risk that if deep geothermal cannot establish itself then it will be seen as non-viable and not be prioritised for support in future.

In contrast to the UK, Germany has increased its revenue support and also introduced other supports mechanisms which have kick-started activity. The following key potential support interventions have been identified from Germany:

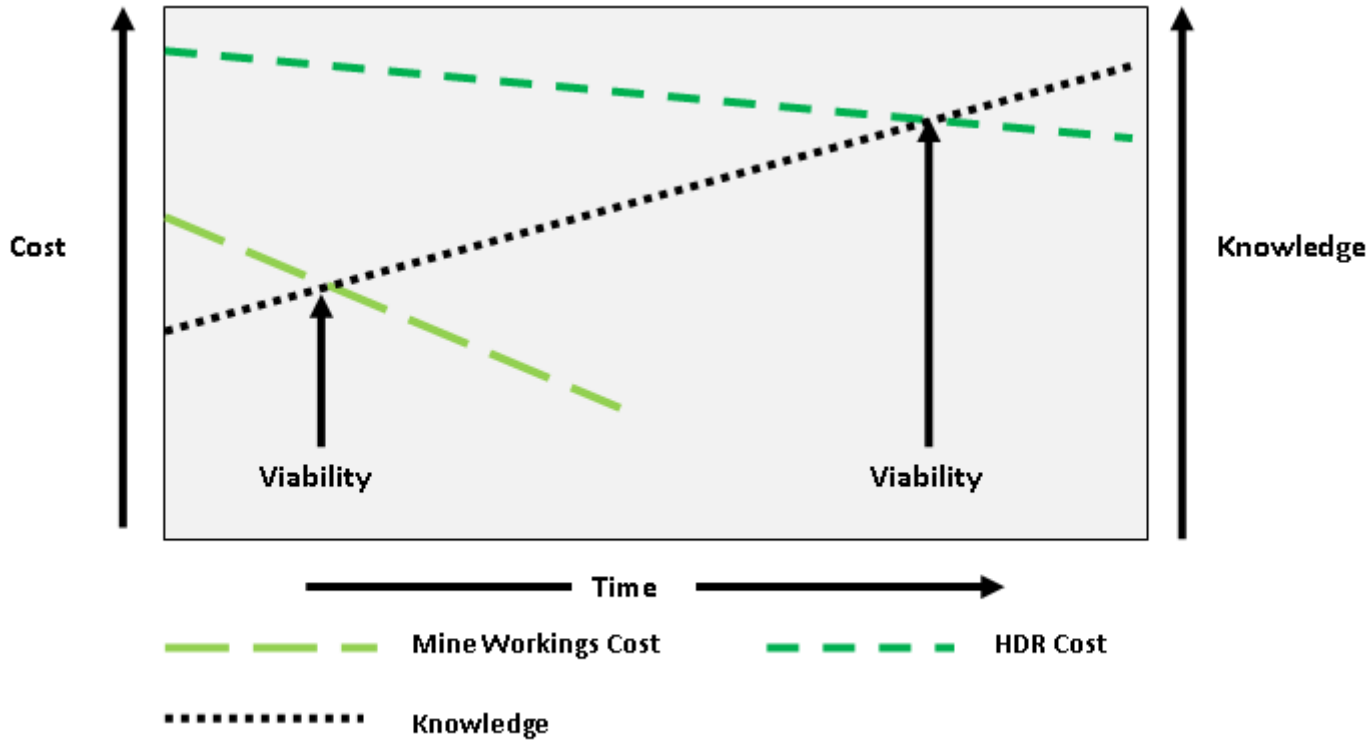
- Provide Grants / Loans to Fund Early Stages – this would provide funding to assist with covering the risky exploration drilling phase. In the case of grants these could be repayable when resource is established (through re-financing) or repaid over the life of the project out of generated revenues.
- State-Backed Exploration Risk Insurance to Cover Early Stage Drilling - Pays out if the predicted resource is not proven.

It is noted that all intervention (beyond ROC/FiT/RHI) may be technically and contractually complex to implement.

It is noted that any Scottish or UK state interventions or support must be considered in the context of European State Aid regulations and must not infringe these.

Figure 7.5 is a schematic illustration of the anticipated inter-relationship between cost, resource and technical knowledge (and experience) over time, comparing geothermal energy from mine workings and HDR sources, and indicating the theoretical point of viability. This illustrates that geothermal energy from mine workings sources is likely to become viable a significant amount of time before geothermal energy from geothermal energy from HDR sources.

Figure 7.5 Schematic illustration of the anticipated relationships between cost, knowledge and viability over time, comparing geothermal energy from mine workings and HDR sources.



As the geothermal resource evidence base increases, the potential risks will be reduced, and it will be easier to get private funding without the requirement for intervention. It is anticipated that the required revenue support mechanisms and interventions could reduce as the cost of financing reduces.

A significant point to note is that developing geothermal resources for heat-only is much less risky than for power production. Heat-only schemes should be advanced as the priority. The experience gained in developing these schemes will help establish the skills required and investor confidence before tackling the much deeper power and heat schemes.

7.7 Exploration Risk Insurance

7.7.1 The Requirement for Exploration Risk Insurance

The provision of exploration risk insurance is considered to be a necessary requirement for the early stages of the development of the deep geothermal energy industry in Scotland, to attract investment and to be able to compete at an international level.

Its usefulness for shallower and / or lower-risk heat-only schemes is less clear. A view expressed by a developer at the project stakeholder workshop stated that it was not required for the type of schemes that they were developing and actually added cost onto the bottom line of the project.

7.7.2 Potential State Aid Issues Relating to Exploration Risk Insurance

The Scottish Government's State Aid Unit (SAU) were consulted on the issue of whether or not a Government-backed exploration risk insurance scheme would constitute State Aid. The SAU stated that the provision of risk insurance would essentially entail the Scottish Government 'guaranteeing' the cost of such an investment, therefore the guidelines which would appear to provide the best fit with such an aim are those on State Aid in the form of Guarantees (Ref. 2008/C 155/02).

Section 3.2 of this provides the basic rules on guarantees, including "(c) The guarantee does not cover more than 80% of the outstanding loan or other financial obligation" and part (d) then explains the need to set a market-oriented price for the guarantee and how this should be done.

The SAU concluded that if these guidelines are followed, then the (European) Commission considers that there will be no State Aid present as the beneficiary is not being conferred an advantage beyond that which the market might reasonably provide.

It therefore appears that the Scottish Government would potentially be able to offer an exploration risk insurance scheme (in the form of a guarantee) up to the value of 80% of the cost without infringing State Aid rules.

7.7.3 Potential State Funding of Exploration Risk Insurance

The funding of risk insurance scheme by the Scottish Government is however a complex issue. The Scottish Government have advised that, under the existing financing system, the value of the exploration risk insurance would need to be set aside within their budget, whether or not it needed to pay out. This would almost certainly impact on capital support for other technologies and initiatives (not just renewable technologies).

It is a matter of choice and priority for the Scottish Government whether they would support deep geothermal in this manner, for example instead of supporting another form of renewable energy in some way. It is anticipated that this would most likely be decided on the predicted return for the level of 'investment' which may appear to be less favourable for deep geothermal energy projects (at least in the short term), due to the high costs and risks involved, than for other renewable technologies. It may therefore be difficult for the Scottish Government to justify 'support' of deep geothermal energy projects by providing exploration risk insurance.

7.7.4 Proposed European Geothermal Risk Insurance Fund (EGRIF)

The European Geothermal Energy Council (EGEC) have recognised that the lack of commercially affordable exploration risk insurance, either public or private, is holding back

development of geothermal resources in Europe. This is partly due to the current lack of the knowledge of the resource which leads to a view by insurers of it being high risk.

In their policy paper on Financing Geothermal Energy (EGEC, 2013). EGEC propose a European Geothermal Risk Insurance Fund (EGRIF) to help encourage investments in geothermal electricity projects. The EGRIF is intended to work through a pooling of the resource risk among geothermal electricity projects across the European Union. The intention of the insurance would be to cover the cost of a geothermal well in case of partial or total failure. It is intended by EGEC that the EGRIF would be financed by a combination of public funds, private funds and project developers funding. It is intended that the EGRIF would cover short and long term risks.

7.8 Geothermal Resource Definition

A programme of exploration and data gathering was undertaken in Australia between 2006 and 2011, by Geoscience Australia, to improve the existing knowledge about the type and location of geothermal resources in Australia on a national scale ('Geothermal Energy Project') as part of a wider investigation to identify onshore energy resources (the 'Onshore Energy Security Program'). It aimed to encourage investment, exploration and exploitation of this energy source through provision of pre-competitive geoscience datasets relevant to geothermal energy.

The programme was The exploration has stimulated commercial geothermal activity in Australia, including projects in the Cooper basin.

7.9 Advances in Technology

Advances in technology have the potential to reduce costs in the future.

In their report for Scottish Enterprise, SKM (2012) highlight the development of Resonance Enhanced Drilling by Aberdeen University and the potential this has for increasing drilling rates, including those for geothermal energy. This has the potential to significantly reduce the drilling programme and therefore costs. From the overview provided, it appears that the technology is in its infancy but may be useful and important in the future.

Also of potential interest is the PLASMABIT plasma drilling technology concept currently being developed by Geothermal Anywhere as a "deep drilling system and rock disintegration method" by a special system based on electric plasma and offering the potential for high drilling progress rates at depth (high temperature and high pressure environments).

Other technological advances in drilling are also under development.

7.10 Discussion & Conclusions

Relative Levels of Risk

There is a clear and significant technological, risk and cost differential between those geothermal developments that generate power (and produce subsidiary heat) – requiring boreholes to significant depth (5km), and those that produce only heat.

There is an increasing risk with depth for geothermal developments:

- Least risk – shallow to moderate depth (say <1km deep) hydrothermal heat-only developments, e.g. in former mine workings.
- Low / Moderate risk – deep (say 1km to 3km deep) heat-only hydrothermal developments, e.g. in Hot Sedimentary Aquifers.
- Moderate / High risk - deep (say 3km deep) power-generating hydrothermal projects developments, e.g. in Hot Sedimentary Aquifers.
- Highest risk – deep (say 4km to 5km+) power-generating petrothermal projects, potentially requiring EGS.

The temperature and properties (permeability flow rates, etc) of a resource can only be confirmed by exploratory drilling.

Shallow to Moderate Depth Heat-Only Geothermal Developments

These projects are considered to be the least risky. If used for domestic or commercial heating purposes it is anticipated that they would be used in conjunction with heat pumps (dependent on the application), makes them slightly less attractive in terms of energy efficiency and carbon production. There are industrial or horticultural processes that could use the ‘warm’ water without the requirement for heat pumps.

There is a reasonable understanding and comprehensive range of information available for mine workings in central Scotland as a potential geothermal energy source. These have the advantage of often being located near centres of population and in particular heat poverty. The use of mine water with heat pumps has been proved in Scotland at a small scale in the schemes at Lumphinnans and Shettleston.

The geothermal mine water project at Herleen in the Netherlands is a positive demonstration the technology and integration with a heat network. Herleen’s originally proposed sister project at the Shawfair development in Midlothian, based on extracting heat from the former Monktonhall colliery, did not go ahead.

Consideration should be given to creating a geothermal demonstrator with a heat network, at Shawfair (as previously proposed) or within another suitable proposed development. If located at Shawfair it could bring benefits to the proposed development and would also benefit from the

previous research. It could also be used as a demonstrator for a mixed-source heat network (a heat engine was also proposed for the Shawfair project).

Deep Heat-Only Hydrothermal Developments(say 500m to 3km deep)

These projects would use the geothermal heat resource as a direct source for domestic or commercial heating purposes or industrial use. The increased drilling costs make these projects riskier than shallower projects.

There is some geological understanding of the properties of Hot Sedimentary Aquifer sources in Scotland form exploratory drilling for hydrocarbons. Similar schemes are currently being proposed in Manchester using the Cheshire Basin aquifer as a source, at circa 3km depth.

It is considered that some further exploration would be required to define the potential of the resources, including the temperature and permeability of the resource.

Power-Generating Geothermal Developments (Hydrothermal & Petrothermal)

It may be possible to generate power from the hydrothermal HSA in Scotland, however, generating efficiency decreases rapidly with decreasing resource temperature.

For the deeper Petrothermal resources, based on the current understanding of the resource (low confidence level), power generation may need to rely on EGS to access the resource and a binary-process to generate electricity. EGS is yet to be widely proved as a commercially viable technique.

There is significant doubt over heat flow and therefore the resources available from buried granites in Scotland. Until drilling takes place to investigate the resource this doubt will remain.

At present there is little prospect of commercialisation of deep geothermal power generation in Scotland in the short-term. This is due to the current lack of information on the location of resources at sufficiently high temperatures that are at technically and economically feasible depths.

It is noted that the current proposed geothermal projects in Cornwall (including those at United Downs in Redruth and at the Eden Project) have benefited from the (higher) certainty provided by high recorded heat flows and the long-running Hot Dry Rock Geothermal Project at Rosemanowes. Both of these projects have been awarded substantial grant support but it is understood that they have not yet secured the full finances required for deep drilling to prove the resource.

To define the likely geothermal resources that may be suitable for power generation, and also to significantly benefit the accuracy and spatial distribution for heat production, a national programme of exploration is required.

In addition, there is no publicly-backed exploration risk insurance scheme and private insurance is unlikely to be affordable to potential developers.

As the geothermal resource evidence base increases, the potential risks will be reduced, and it will be easier to get private funding. It is anticipated that the required support mechanisms could reduce as the cost of equity reduces.

It is noted that, amongst others, the German government has stimulated activity in the deep geothermal sector by providing a range of support measures, including a generous FiT (with bonuses for HDR projects), exploration risk insurance and grants.

7.11 Recommendations

Two sets of recommendations are made; one set for heat-only developments and one for power-generating developments.

Geothermal heat is much less risky than deep geothermal electricity production and it is recommended that it should be targeted as a priority for development.

Geothermal power is dependent on better definition of the resource. An exploration programme should be commenced, in parallel with developing the shallower resources.

Unlocking the Potential of Shallow Geothermal Heat-Only Projects

The development of heat networks is considered essential to the deployment of geothermal heat resources. Identification of initial anchor heat load(s), most likely from public buildings, is a key element in establishing the viability of heat networks. It is recommended that the opportunities for development where resource and demand coincide should be identified by combining the geothermal resource potential maps from this study and heat mapping.

It is recommended that a geothermal demonstrator with a heat network should be developed, for example at Shawfair (as previously proposed) near Edinburgh, Clyde Gateway in eastern Glasgow, or within another suitable and suitably-located proposed development / area. It could provide a focus to encourage development and help build a sustainable community and or commercial or industrial park (or mixed-use development).

It is considered that the RHI level of 5p/kWh currently proposed by DECC could make the business case for deep geothermal heat developments (>500m depth) sustainable.

The experience gained from developing progressively deeper projects will aid in establishing confidence in the sector and reducing costs.

Unlocking the Potential of Deep Geothermal Power Projects

It is recommended that a programme of data gathering and exploration is undertaken, with a similar scope to the recent exploration programme in Australia that has stimulated commercial geothermal activity. This will help to reduce the uncertainty and therefore the risks to help encourage commercial development.

This would include:

- Collating available data from all public sources, and potentially private sources, into a national geothermal information database and making it freely available to for the benefit of all.
- A national exploration programme of investigation specifically to identify the location of deep buried granites.
- A targeted programme of deep drilling to prove deep resources and research the potential.

A key element is proving or disproving the theory that the geothermal temperature gradient in Scotland was suppressed by the last ice age to a significant depth and has not fully rebounded. If this theory is correct then substantial undiscovered resources may exist at depth.

Dependent on further definition of the resource, ROCs are considered a good support mechanism for development of the deep geothermal power generation, if it is pitched at right level. It is recommended that a level of 4 to 5 ROCs be adopted for deep geothermal as an emerging technology that has the potential to provide baseload. This is also to provide more parity with other countries, specifically European countries.

Additional funding support is also likely to be required to attract developers. It should be noted that any state funding would be subject to State Aid regulations.

Consideration should be given to a Scottish Government backed deep geothermal exploration risk insurance scheme similar to the schemes that are in place in most other countries that are developing geothermal resources. It is acknowledged that this is a complex issue and it may be difficult for the Scottish Government to justify ‘support’ of deep geothermal energy projects by providing exploration risk insurance at the expense of support of other renewable technologies.

It is recommended that the Scottish Government investigates how it can offer or encourage some form of exploration risk insurance.

As an alternative or in addition to direct funding from the Scottish Government, it is recommended that it should be investigated whether other institutions could provide exploration risk insurance (for example the Green Investment Bank or the commercial insurance sector). The European Geothermal Risk Insurance Fund proposed by EGEC may also provide an alternative but is currently only a proposal.

Conclusions and Summary of Recommendations

8 Conclusions and Recommendations

8.1 Introduction

Realisation of commercialisation of the deep geothermal energy sector in Scotland will require a strong partnership between the Scottish Government, government agencies, developers and other stakeholders. It is anticipated that the Scottish Government have a significant role to play in initially establishing the industry sector, particularly in terms of financial support. In time, as private sector confidence in the sector grows, the support could reduce appropriately.

It is recommended that the following key actions are undertaken by the Scottish Government in order to encourage and facilitate development of the sector.

A progressive and phased approach to developing Scotland's geothermal resources is advocated to build confidence, reduce costs, and thereby encourage private investment.

8.2 National Geothermal Energy Vision Statement and Strategy for Scotland

It is recommended that a clear Vision Statement is developed and a Strategy for its delivery is also developed and then implemented. This would serve to direct and realise the development of the geothermal energy sector in Scotland.

Both the Vision Statement and Strategy should be directly linked to existing Scottish Government policies on renewable energy and heat, including the 2020 Routemap and associated policies but also specifically and importantly the Outline Heat Vision.

It is not intended that these should be exhaustive documents or take a long period to produce; resources and effort should be directly channelled into progressing the development of the geothermal resources themselves, however the Vision Statement and Strategy are considered to be key enablers.

8.2.1 Vision Statement

The purpose of the proposed Vision Statement is to define the Scottish Government's ambition for geothermal energy development in Scotland, and to set goals to be reached at certain defined points in the future.

It is anticipated that the Vision Statement will present a progressive approach to developing Scotland's geothermal resources with targets for:

- Short to medium term (say 0 to 10 years+) - developing the supply of heat from geothermal resources and the tie-in with allied technology and infrastructure development for distributing and utilising heat, i.e. combined heat and power plants, district heating networks, etc.
- Medium term (say 5 to 10 years+) - potential development of deeper Hot Sedimentary Aquifer (HSA) systems for heat and potentially generation of baseload electricity.

- Medium to longer term (say 5 to 20 years+) - potential development of deeper Hot Dry Rock resources using Enhanced Geothermal Systems (EGS) for generation of baseload electricity as the knowledge base, market confidence and technology advances.

Experience gained from development of progressively deeper schemes will increase market confidence, reduce costs, and thereby encourage private investment.

8.2.2 Strategy

The proposed Strategy is the routemap that will outline how the Vision Statement for geothermal energy development in Scotland will be achieved.

The Strategy will have several strands, technical, administrative, regulatory and commercial. The general suggested content of these is highlighted in the sections below, but would not be limited to these alone.

8.3 Geothermal Demonstrator Projects

8.3.1 Initial Demonstrator Project (Heat Only)

In order to increase confidence in the geothermal resources and technologies, it is recommended that a geothermal demonstration and evaluation project (or projects) is developed and installed as soon as feasibly possible.

This would be a full scale working scheme, supplying heat to an identified demand, be it domestic or commercial or some combination of the two.

The demonstrator should be a heat-only project most likely utilising abandoned mine workings as the geothermal resource. The advantages of the abandoned mine workings are that there is a wealth of information available on them, they are accessible in terms of depth and they coincide in many parts with the major population centres in central Scotland.

The two existing small-scale schemes in Scotland that utilise abandoned mine workings have already demonstrated that this resource can be used to heat homes at a relatively small scale. The demonstrator would seek to replicate this at a significantly larger scale, the scale itself being dependent on the resource and the nature of demand.

To identify the potential opportunities to site the demonstrator project the resource availability mapping needs to be combined with existing / predicted heat demand (from heat mapping). Once these geographical areas have been defined, specific heat demand opportunities need to be identified.

Heat demand opportunities could comprise (but are not limited to) housing, commercial buildings, industry, horticulture, aquaculture, public buildings, combined heat and power plants (as a ‘warm’ water supply to increase efficiency). These could be by conversion of existing stock or facilities, or a new build opportunity.

Potential opportunities are known to exist in and around Scotland's two largest conurbation areas; Glasgow and Edinburgh.

For example, the BGS has undertaken a significant amount of research to produce a three-dimensional model of the strata underlying Glasgow, including abandoned mine workings. This is now being utilised in research work being undertaken at Glasgow Caledonian University(and part funded by Scottish Power) to map abandoned mine workings that is currently. This is particularly focussing on the Clyde Gateway area in eastern Glasgow, and allied with the significant ongoing regeneration in this area, opportunities are likely to exist for a demonstrator project.

A significant amount of work was also previously undertaken as part of a European Union project on utilising mine waters of the former Monktonhall Colliery as a source of heat for a development at Shawfair in Midlothian on the outskirts of Edinburgh as part of a major residential and business development (PB Power, 2004). The mine water project at Shawfair did not go ahead; the reasons for this are not known but have been been attributed variously to landowner issues or a lack of economic viability. In addition the residential development was later cancelled due to economic conditions. A sister mine water project at Herleen in the Netherlands was successfully installed. An opportunity exists to either resurrect this project or identify other opportunities local to this area that could utilise mine water from Monktonhall. The new Shawfair railway station on the reinstated Waverley Line (Borders Rail project) may act as a catalyst for renewed interest and development in this area.

Once opportunities are identified, site specific feasibility studies should be undertaken on the best of these and the overall most certain and beneficial project should be selected as the demonstrator(s).

The options for funding need to be fully explored and this is beyond the scope of this report. As this would be a demonstrator project, aimed at encouraging future investment, it is considered that additional funding from the government (Scottish or UK) would be required to encourage investment. It is envisaged that the demonstrator would be developed and operated by a private company with allocation of funding on a competitive basis, either to a single project or to multiple competing projects. It may be possible to encourage the private funding in return for an incentive, for example a guaranteed purchase of heat energy by a public body for a contracted period.

8.3.2 Deep Demonstrator Projects (Heat and Electricity Generation)

Following the implementation of the National Geothermal Exploration Programme (see following section), it is anticipated that demonstrator projects may be required for deeper resources (HSA and HDR). This is due to the high level of risk associated with such deep drilling.

The opportunities for locating these initial projects can only be determined following the exploration programme. SKM (2012) previously assessed the case for a deep demonstrator project for Scottish Enterprise and their report contains useful information but identifies significant information gaps.

A deep demonstrator project could be ultimately achieved by progressively advancing a research and evaluation borehole, with further advancement to the next depth only on proving of certain conditions at each stage, e.g. geothermal gradient (below the glacially-effected zone), heat flow, geological conditions, etc. This however may take a significant length of time to complete and would require policy stability over the term of the investigation.

SKM (2012) also raised the possibility of extending existing borehole(s) at the Weatherford Evaluation Centre (WEC) near Bridge of Don, Aberdeen. However, this would be dependent on geological conditions being suitable for an evaluation well / demonstrator, and the cooperation of Weatherford, a commercial organisation in the oil and gas services sector.

A key principle of the Scottish Government's heat vision is to recover as much 'waste' heat as possible. Therefore any deep geothermal power plant developed in the future should, for demonstration purposes, recover as much 'waste' heat as possible for other uses and should therefore be a combined heat and power (CHP) plant.

8.4 National Geothermal Exploration Programme

Many of the barriers to development of the geothermal sector in Scotland centre around our current knowledge level of the resource. In particular, geothermal gradients and heat flow is poorly understood and there is a poor understanding of potential Hot Sedimentary Aquifers (HSA) and High Heat Production (HHP) granites ('HDR') at depth. Both of these are primarily due to the lack of suitable deep onshore borehole data.

In parallel with the Geothermal Demonstrator Project, and to advance the development of deeper geothermal resources in Scotland, a National Geothermal Exploration Programme is recommended. This would be undertaken in three parts as outlined in the following sections:

- Creation of a National Geothermal Database;
- Research programme for deeper prospects; and
- Physical exploration programme.

It is recommended that the exploration programme is phased to concentrate on the most promising regions already identified by this study and to advance development of these resources and the sector as quickly as possible.

The linkages between this proposed programme to any other existing and planned investigation programmes is still to be established.

8.4.1 National Geothermal Database

The creation of a National Geothermal Database would provide a central source of relevant information for both onshore and offshore data for stakeholders, potential developers and researchers. The current lack of deep onshore borehole data in Scotland will mean that while

offshore geothermal resources may not be exploited commercially in the near future, offshore data will be important for correlating with onshore data.

The database would remain live and be maintained, receiving and storing new data as it becomes available to further define the resources available. Initially data would be gathered from all available sources and it is hoped that the data would be supplied by relevant organisations on a cooperative partnership and collaboration basis, in the national interest, with the benefit of open access for all interested parties. It is envisaged that formal legal agreements would be put in place with the relevant organisations to protect their interests and control use of the data by third parties. Some data may be commercially sensitive and organisations are unlikely to release such data until it ceases to be commercially sensitive (if ever).

Organisations likely to hold significant amounts of relevant data include:

- DECC (data from oil and gas exploration, including bottom-hole temperature data)
- The BGS (various data sets of potential relevance)
- The Coal Authority (coal mining data)
- Ground Source Heat Pump industry (near-surface data)
- Oil and gas exploration and production companies (data from oil and gas exploration and production).

A suitably qualified and experienced research or regulatory body would be required to host, operate and maintain the database. As the state body responsible for geological data, it is considered that the BGS would be well placed to carry out this service.

8.4.2 Research programme for deeper geothermal prospects

A programme of geological research into the deeper prospects is required to review and reinterpret existing data, particularly relating to identified thermal anomalies and HHP granites (including buried granites).

The creation of the National Geothermal Database will make data available to allow modelling of the deep geothermal gradient (temperature variation with depth) and heat flow.

Where not already available, heat production data for all significant exposed granite intrusions across Scotland should be obtained and the fracture networks in identified HHP granites should be characterised.

The ultimate aim of the geological research programme is to further define the most likely regions for deeper geothermal prospects.

8.4.3 Physical exploration programme

It is anticipated that the physical exploration programme will be in two parts, geophysical survey on a regional basis and deep drilling once specific target resources have been identified.

The targeted geophysical survey will be used to determine the three-dimensional geological structure of the identified region(s) and help define the extent of potential geothermal resources. The types of geophysical survey employed will be dependent on the particular geological conditions but could include aeromagnetic, gravity, radiometric imaging, electromagnetic, seismic (reflection, refraction and tomography).

Deep drilling will ultimately be required to investigate the suitability of the potential deep geothermal resources identified from the research programme and geophysical surveys. The primary aims of the deep drilling will be to determine the properties and thickness of overlying strata, the nature of the resource, including groundwater conditions (if any), temperature, structure, fracturing, major faults/fault zones, porosity, permeability (natural, unenhanced) and the existing stress regime.

As the cost of deep drilling is extremely high it is anticipated that, subject to suitable conditions being encountered, that a deep exploration borehole could be converted into a production well (other production wells would also need to be drilled in addition to the deep exploration borehole). This may be as a deep demonstrator project (see preceding section).

8.5 Resource Ownership & Licensing

The legal ownership of geothermal resources is not currently defined under existing legislation. The uncertainty of ownership of geothermal resources is a potential risk for individual projects, which along with risks associated with geological uncertainty, gives rise to increased cost and can make it difficult to obtain sufficient finance to develop deep geothermal projects.

A clear definition of what comprises geothermal energy is vital in establishing ownership of the resource and determines whether it is defined in legislation as a mineral, water or heat/energy.

From the review of legal ownership and existing licensing regimes, it is considered that creation of new, specific legislation is the preferred option. Key requirements for a potential geothermal licensing regime have been identified.

It is recommended that the legal ownership of geothermal energy resources should be established to allow a geothermal resource licensing system to be established. It is considered that this can only be undertaken by amending existing primary legislation or introducing new primary legislation.

It is recommended that new primary legislation should be introduced, a proposed ‘Geothermal Energy Act’, to include claim ownership of geothermal resources and implement a licensing system for geothermal resources.

It is expected that the rights to geothermal energy resources would be claimed on a UK-wide basis and rights then licensed by a UK Government agency (for example DECC), or possibly the powers for Scotland could be ‘transferred’ to the Scottish Government.

It is recommended that the Scottish Government liaises with DECC to determine whether establishing legal ownership (and introduction of a licensing system) can now be taken forward as UK priority, or alternatively, how this can be undertaken by the Scottish Government.

It is also recommended that the Scottish Government, in conjunction with DECC, reviews the potential political opportunities and timescales for introduction of the proposed Geothermal Energy Act, and potential interim legislation.

It is anticipated that given the likely timescale involved in drafting new and specific geothermal resource licensing legislation (several years), interim measures are required to encourage commercial investment in the short term and medium term. It may be appropriate to follow a two stage approach to legislation, initially creating relatively simple interim exploration and development legislation, as an amendment to existing legislation, to be replaced at a later date with more comprehensive and stand-alone legislation, as the industry develops and matures.

It is recommended that in the intervening period before any amended or new legislation can be introduced, geothermal development is controlled through the development management (planning) regime through the EIA process. Some changes to planning guidance would be required to enable this. It is recommended that SEPA are consulted by the Scottish Government regarding this issue as they would be the primary consultee for both relevant EIA issues and groundwater abstraction.

The enactment of geothermal resource licensing should be such so as not to inhibit the take-up of GSHP technology. It is therefore recommended that geothermal resources shallower than 200m depth should be either exempted from future licensing or made subject to general rules.

8.6 Environmental Regulation

Environmental legislation relating to assessment and consenting issues are based on various European Directives and associated UK and / or Scottish legislation or regulations and these are well established in Scotland.

Although, the existing framework of legislation could control geothermal development in Scotland, some changes to the legislation should be considered.

Activities relating to deep geothermal projects are specially identified in Schedule 2 of the EIA Regulations 2011. It is noted that under the existing Regulations, EIA for deep geothermal development is only likely to be required if the surface footprint of the development is greater than 0.5 hectares, regardless of the sub-surface extent of the geothermal developments.

Activities relating to geothermal projects are specially identified in Schedule 3 of the Water Environment (Controlled Activities) (Scotland) Regulations 2011, with further discussion provided in relevant SEPA guidance notes. Currently a potential gap in regulation exists as water abstraction and reinjection for geothermal developments is covered by general binding rules (specifically GBR17) and SEPA would not need to be consulted regardless of the actual water

volumes, unless the difference between the two was greater than 10m^3 per day (notwithstanding the requirements for 'complex' boreholes i.e. >200m depth).

Hydraulic fracturing may, in the future, be required to develop deep engineered/enhanced geothermal systems (EGS) for electricity generation and heat production from deeper resources. Hydraulic fracturing is unlikely to be required for the development of heat-only geothermal schemes. Seismic risk assessment is likely to be seen as good practice for developments involving hydraulic fracturing.

The following key recommendations are made in relation to the environmental regulatory regime for deep geothermal energy.

- It is recommended that the Scottish Government clarifies whether EIA should consider the surface and / or sub-surface extent of potential geothermal developments and advice issued accordingly (see also Resource Ownership & Licensing).
- It is recommended that the Scottish Government considers specific reference to "deep geothermal" or "geothermal" when drafting future environmental legislation.
- It is recommended that SEPA produce a detailed specific Regulatory Guidance document for deep geothermal development.
- It is recommended that SEPA should consider whether the existing CAR GBR's relating to abstraction licences for geothermal energy developments are appropriate to future larger-scale geothermal developments which may be abstracting and re-injecting large volumes of water.
- It is recommended that SEPA should clarify what constitutes groundwater heating or cooling pollution in relation to geothermal developments.
- It is recommended that geothermal energy should be listed by SEPA as a NORM Industrial Activity in a future revision of the Regulations. In the interim, good practice would dictate that developers should adhere to the Regulations as if geothermal energy was included.

8.7 Planning Policy

In relation to considering national planning policy in the context of and achieving the Scottish Government's ambitious targets for renewable/low carbon and decentralised sources of energy, geothermal energy is a good source of renewable and low carbon heat. A supportive planning framework is considered to be important to encourage commercialisation of geothermal energy in Scotland.

There is currently a perceived lack of policy coverage for deep geothermal energy. Dealing with primary planning impacts in terms of policy context requires strategic level support.

Geothermal energy developments are likely be classified as ‘Local Developments’ under the Hierarchy Regulations. Geothermal energy may become of national significance as an energy source in the future. A key challenge is therefore including and promoting geothermal energy at national planning policy level.

The following are the key recommendations:

- The NPF3 main issues report is currently under consultation and it is recommended that geothermal energy is specifically included in NPF3;
- It is recommended that the Scottish Government should develop a specific strategy for the development of geothermal energy (similar to the strategy for the development of marine renewable energy);
- It is recommended that the Scottish Government should consider specifically including geothermal energy at national planning policy level in the revised SPP. This could include a statement on a presumption favour of geothermal developments;
- To achieve renewable heat energy targets and the desired uptake, it may be necessary to require new-build developers to install district heating systems. It may be possible to encourage or incentivise developers to include geothermal energy as the, or part of, the heat source;
- Planning Authorities require the expertise to assess geothermal energy applications. The current perceived lack of clarity and specific advice could potentially lead to delay in determination of applications. Supplementary specific planning guidance (SPG) for deep geothermal energy should be developed;
- It is recommended online renewables planning advice on deep geothermal is revised to provide more specific advice, reflect the current understanding of available resource, and differentiate clearly between shallower heat-only schemes (the likely future majority of schemes) and deeper power and heat schemes;
- Circular 2/2011 relates to renewable energy for non-domestic microgeneration. It is recommended that the Scottish Government may wish to consider amending Circular 2/2011 to specifically allow small-scale geothermal heat energy within permitted development in a similar manner to GSHP systems;
- It is recommended that policies on geothermal energy are adopted by planning authorities in the next review of their Strategic Development Plans and Local Development Plans;
- Deep geothermal (>200m depth) should be included in current and future reviews of Local Development Plans as the review cycle dictates. Planning Authorities require information on the spatial distribution of both deep geothermal resources and heat demand, so that they can be linked;

8.8 Costs and Financing

As highlighted elsewhere in this report, there are currently significant differential in technological, risk and costs uncertainty between relatively shallow heat-only developments (relatively low risk) and deeper primarily electricity-generating developments (relatively high risk).

It is anticipated that experience gained from the demonstrator project(s), and progressively deeper schemes will increase developer and investor confidence and reduce costs and thereby encourage development. Shallower heat-only developments are likely to be viable a significant period of time before deeper developments.

The German government has stimulated activity in the deep geothermal sector by providing a range of support measures, including a generous FiT (with bonuses for HDR projects), exploration risk insurance and grants.

The proposed Renewable Heat Incentive (RHI) of 5.0p/KWh for 2013 is welcome support for deep geothermal (defined as schemes >500m depth under the RHI) and could help to start unlocking the geothermal development potential.

With regard to electricity generation from geothermal sources, i.e. from HDR sources only, SKM (2012) undertook a revenue assessment based on their estimated costs for a relatively small-scale deep geothermal demonstrator project. This indicated a significant funding gap of approximately £700/MWh based on the current 2 ROC level of support, with only a slightly reduced funding gap of approximately £620/MWh for a theoretical 5 ROC level of support.

It is considered that for an emerging technology, with the potential to provide baseload electricity generation, the level of support should be increased to 4 to 5 ROCs.

Even with a significantly increased ROC level of support, the funding gap would still be large and significant government additional funding and / or some alternative funding mechanism would currently be required to attract and encourage deep geothermal developments for electricity generation. As discussed above, costs should reduce over time, and confidence increase, such that in the future the level of additional funding would be reduced and ultimately may not be required.

DECC previously issued grants under the Deep Geothermal Challenge Fund. Funds were allocated to both heat-only and electricity-generating schemes. None of the current UK electricity-generating schemes have currently proceeded due to shortfalls in total project funding. The future intentions for funding of deep geothermal projects by DECC is unknown.

Any additional state funding would be subject to State Aid regulations.

It is recommended that the Scottish Government investigates how it can act unilaterally to support deep geothermal projects in Scotland, potentially setting up its own deep geothermal fund. This could potentially initially be used as a mechanism to fund the proposed demonstrator project(s).

Geothermal exploration risk insurance has been requested by some potential geothermal developers to encourage otherwise risky investment. However, the Scottish Government have advised that under the existing internal government budgetary arrangements the ‘insurance’ provisions would have to be covered with an actual budgetary sum, thereby potentially depriving other areas of those funds, which would be difficult to justify.

It is recommended that the Scottish Government investigates how it can offer some form of exploration risk insurance.

As an alternative or in addition to direct funding from the Scottish Government, it is recommended that it should be investigated whether other institutions could provide exploration risk insurance (for example the Green Investment Bank or the commercial insurance sector). The European Geothermal Risk Insurance Fund (EGRIF) proposed by the European Geothermal Energy Council (EGEC) may also provide an alternative but is currently only a proposal.

Key Next Steps for Developing Deep Geothermal in Scotland

9 Key Next Steps for Developing Deep Geothermal in Scotland

9.1 Key Actions

A progressive and phased approach to developing Scotland's geothermal resources has been recommended to build market confidence, reduce costs, and thereby encourage private investment.

It is anticipated that a Vision Statement will present a progressive approach to developing Scotland's geothermal resources with targets for the short, medium and longer term.

Key actions have been identified that are currently required to advance the development and commercialisation of deep geothermal energy sector in Scotland. These are based on the key recommendations of this report.

The key actions identified are summarised in Table 9.1.

Table 9.1 - Key Actions for Deep Geothermal Energy in Scotland

Ref:	Key Action:	Action By:	Recommended / Anticipated Timescale:
1	**National Geothermal Energy Vision Statement and Strategy for Scotland**	SG	2013/14
2	**Geothermal Demonstrator Projects**		
	a. Initial Demonstrator Project (Heat Only)	SG, LA's & PD's	2014-2016
	b. Deep Demonstrator Projects (Heat and Electricity Generation)	SG, LA's & PD's	2018+
3	**National Geothermal Exploration Programme**		
	a. Creation of a National Geothermal Database	SG & BGS	2014
	b. Research programme for deeper prospects	SG & BGS	2014-2017
	c. Physical exploration programme	SG & BGS	2016-2018+
4	**Resource Ownership & Licensing**		
	a. Interim control of geothermal developments: amendment of Planning Advice to control through Development Control (EIA).	SG, PA's & SEPA	2013/14
	b. Liaison with DECC about establishing legal ownership and introduction of a licensing system either as UK priority or how this can be undertaken unilaterally by the Scottish Government.	SG & DECC	2013/14
	c. Review of potential political opportunities and timescales for introduction of proposed potential interim amendment of existing legislation (exploration and development phase) and new legislation for geothermal licensing (production phase).	SG & DECC	2013/14
	d. Introduce 'Geothermal Energy Act', to claim ownership of geothermal resources and implement a licensing system	SG or DECC	2018-2020?
5	**Environmental Regulation**		
	a. Detailed specific Regulatory Guidance document for deep geothermal development to be produced.	SEPA	2013/14
	b. Consideration of whether the existing CAR GBR's are appropriate to future larger-scale geothermal developments which may be abstracting and re-injecting large volumes of water.	SEPA	2013
	c. Clarification of what constitutes groundwater heating (or cooling) pollution in relation to geothermal developments.	SEPA	2013

6	**Planning Policy**		
	a. Consideration of specifically including geothermal energy at national planning policy level in the revised SPP and inclusion of a statement on a presumption favour of geothermal developments.	SG	2013
	b. Inclusion of geothermal energy is specifically included in NPF3.	SG	2013
	c. It is recommended that supplementary specific planning guidance (SPG) for deep geothermal energy should be developed.	SG	2013
	d. Inclusion of policies on geothermal energy are adopted by Planning Authorities in the next review of their Structure Plans, Strategic Development Plans and Local Plans.	PA's	Various (ongoing cycle)
	e. Provision of spatial distribution of deep geothermal resources to Planning Authorities, so that it they can be combined with heat demand (identified from heat mapping) and so the two can be linked.	SG & PA's	2013
	f. Consideration of allied policies compelling certain types of new-build development e.g. to install district heating systems and incentivise inclusion of geothermal energy as part of the heat source.	SG & PA's	2013/14
7	**Costs and Financing**		
	a. The level of support for deep geothermal should be increased to 4 - 5 ROC (or equivalent FiT level).	SG & DECC	2014
	b. Creation of a deep geothermal support fund for projects in Scotland.	SG	2014-2029
	c. Investigation of how SG can offer some form of exploration risk insurance either directly or through other institution(s).	SG & / or GIB	2013-2014

Abbreviations:

SG = The Scottish Government

DECC = Department for Energy and Climate Change

LA's / PA's = Local / Planning Authorities

SEPA = Scottish Environment Protection Agency

BGS = The British Geological Survey

GIB = Green Investment Bank

PD's = Private Developers

References

10 References

1. Air Quality (Scotland) Regulations 2000. Scottish Statutory Instrument No. 97
2. Allen Consulting Group. 2011. Australia's geothermal industry: pathways for development, Final report
3. Australian Government Department of Resources, Energy and Tourism. 2008. Australian Geothermal Industry Technology Roadmap. Commonwealth of Australia
4. British Geological Survey Website http://www.bgs.ac.uk
5. Climate Change (Scotland) Act 2009
6. Coal Industry Act 1994
7. Commonwealth of Australia. 2008. Australian Geothermal Industry Technology Roadmap
8. Conservation (Natural Habitats) Regulations 1994
9. Continental Shelf Act 1964
10. Control of Pollution Act 1974, Part III
11. Cornwall Council. 2012. Renewable Energy Planning Guidance Note 8, The development of deep geothermal
12. DECC website http://og.decc.gov.uk/en/olgs/cms/licences/licensing_guid/licensing_guid.aspx
13. DECC. 2011. The Unconventional Hydrocarbon Resources Of Britain's Onshore Basins - Shale Gas
14. Draft Scottish Statutory Instruments. 2011. Atomic Energy and Radioactive Substances, The Radioactive Substances Act 1993 Amendment (Scotland) Regulations 2011
15. EC Directive (2006/118/EC) Groundwater Daughter Directive
16. EC Directive (80/68/EEC) Groundwater Directive (in force till Dec 2013)
17. EC Directive (92/43/EEC) Habitats Directive: Conservation of natural habitats and of wild fauna and flora.
18. EC Directive (96/82/EC): Control of major accident hazards
19. EC Directive 2000/60/EC Water Framework Directive 2000
20. EC Directive 2001/42/EC: 'Strategic Environmental Assessment' and EC Directive (85/337/EEC) Environmental Impact Assessment: Assessment of the effects of certain public and private projects on the environment
21. EC Directive 2004/35/EC on environmental liability with regard to the prevention and remedying of environmental damage
22. EC Directive 2009/31/EC: Carbon Capture and Storage Directive 2009

23. EC Directive 2010/75/EU: Industrial Emissions Directive
24. EC Directive 96/61/EC: Integrated pollution prevention and control
25. EC Regulation (259/93): Supervision and control of shipments of waste within, into and out of the European Community
26. EC Regulation (3093/94): Substances that deplete the ozone layer
27. Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2000
28. EMEC and Xodus Aurora. 2010. Consenting, EIA and HRA Guidance for Marine Renewable Energy Developments in Scotland", Parts 1 to 4
29. Energy Act 1976
30. Environment Act 1995, Part V
31. Environment Agency. 2011. Deep Geothermal Energy, Our position - regulating deep geothermal energy production.
32. Environmental Impact Assessment (Scotland) Regulations 1999
33. Environmental Protection (Controls on Substances that Deplete the Ozone Layer) Regulations 1996
34. Environmental Protection (Prescribed Processes and Substances) Regulations 1991
35. Environmental Protection Act 1990, Part I
36. Environmental Protection Act 1990, Part II
37. Environmental Protection Act 1990, Part III
38. European Geothermal Energy Council website http://egec.info
39. European Geothermal Energy Council. 2012. GeoDH Promote Geothermal District Heating Systems in Europe, National Workshop – United Kingdom
40. European Geothermal Energy Council. 2013. Fact Sheet on Enhanced Geothermal Systems: Why it is different to shale gas.
41. European Geothermal Energy Council. 2013. Policy Paper on Financing Geothermal Energy.
42. Fluorinated Greenhouse Gases Regulations 2008 (S.I No 41)
43. Goldstein, B., Hiriart, G. Bertani, R. Bromley, C. Gutiérrez-Negrín, L. Huenges, E. Muraoka, H. Ragnarsson, A. Tester, J. Zui, V. 2011. Geothermal Energy. In IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation [O. Edenhofer, R. Pichs-Madruga, Y. Sokona, K. Seyboth, P. Matschoss, S. Kadner, T. Zwickel, P. Eickemeier, G.

Hansen, S. Schlömer, C. von Stechow (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, USA

44. Haraldsson, I.G. 2012. Legal And Regulatory Framework – Barrier Or Motivation For Geothermal Development?
45. Holroyd and Dagg. 2011. Building a regulatory framework for geothermal energy development in the NWT. The Pembina Institute
46. International Energy Agency. 2011. Technology Roadmap, Geothermal Heat and Power
47. Irish Government. 2010. General Scheme of Geothermal Energy Development Bill
48. Irish Government. 2010. Geothermal Energy Development Bill 2010 Regulatory Impact Analysis
49. Irish Government. 2012. http://www.eoghanmurphy.ie/2012/10/04/questions-for-communications-energy-natural-resources/
50. James Hutton Institute, 2011. Geothermal Energy Use and Potential
51. Lee K.C. 1996. Classification of geothermal resources - an engineering approach
52. Lords Hansard. 2011. 8 Feb 2011 : Column GC35, Grand Committee, Tuesday, 8 February 2011, Energy Bill (HL). http://www.publications.parliament.uk/pa/ld201011/ldhansrd/text/110208-gc0001.htm
53. Marine (Scotland) Act 2010 and the Marine and Coastal Access Act 2009
54. Mines (Working Facilities and Support) Act 1966
55. Minewater project. Undated. Mine water as a Renewable Energy Resource
56. Nicholson. D. 2012. Viewpoint - Powering the future, in NCE 18-10-2012
57. Official Journal of the European Union. Commission Notice on the application of Articles 87 and 88 of the EC Treaty to State Aid in the form of guarantees (2008/C 155/02)
58. Ozone Depleting Substances (Qualifications) Regulations 2006 SI 1510
59. PB Power. 2004. Shawfair Minewater Project, Scottish national Minewater Potential Study,Job No. 69211a/001
60. Petratherm. 2008. Geo-Madrid District Heating Project - Well Re-entry Yields 30% Cost Savings.
61. Petroleum (Production) Act 1934
62. Petroleum Act 1998
63. Pipe-line Works (Environmental Impact Assessment) Regulations 2000
64. Pipelines Act 1962

65. Planning (Control of Major-Accident Hazards) (Scotland) Regulations 2000
66. Planning (Hazardous Substances) (Scotland) Act 1997 and Planning (Control of Major Accident Hazards) (Scotland) Regulations 2000
67. Planning and Compensation Act 1991 (as amended) ;and Environment Act 1995 (as amended).
68. Planning etc. (Scotland) Act 2006
69. Poyry and Faber Maunsell/AECOM. 2009. The potential and costs of district heating networks.
70. Radioactive Substances Act 1993
71. Roijen E., Op ‘t Veld P. and Demollin-Schneiders E. 2007. The Minewater project Heerlen - low exergy heating and cooling in practice
72. Scottish Government. 2009. National Planning Framework 2
73. Scottish Government. 2010. Scottish Planning Policy (SPP)
74. Scottish Government. 2011. Planning Circular 2/2011: The Town and Country Planning (General Permitted Development) (Non-Domestic Microgeneration) (Scotland) Amendment Order 2011
75. Scottish Government. 2011. Renewable Heat Action Plan for Scotland: a plan for the promotion of the use of heat from renewable sources. http://www.scotland.gov.uk/Publications/2009/11/04154534/0
76. Scottish Government. 2012. 2020 Routemap for Renewable Energy in Scotland, http://www.scotland.gov.uk/Publications/2011/08/04110353/0 and http://www.scotland.gov.uk/Topics/Business-Industry/Energy/UpdateRenewableRoutemap
77. Scottish Government. 2012. Planning Advice (Specific Advice Sheet), Deep Geothermal Energy
78. Scottish Government. 2013. Outline Heat Vision . http://www.scotland.gov.uk/Topics/Business-Industry/Energy/Energy-sources/19185/Heat/DraftHeatDeployment
79. Scottish Government. 2013. Scotland’s Heat Map (draft). http://www.scotland.gov.uk/Topics/Business-Industry/Energy/Energy-sources/19185/Heat/HeatMap
80. SEPA and The Coal Authority. 2008. Abandoned mines and the water environment, Science project SC030136-41
81. SEPA. 2011. Supporting Guidance Application of Standards to Thermal (WAT-SG-85), v1.0

82. SEPA. 2011. The Water Environment (Controlled Activities) (Scotland) Regulations 2011, A Practical Guide, v6
83. SEPA. 2012. Regulatory guidance: Coal bed methane and shale gas, v121119
84. SEPA. 2013. Regulatory Method Licensing Groundwater Abstractions including Dewatering (WAT-RM-11), v4
85. SEPA. 2013. Supporting Guidance for Groundwater Abstractions – Geothermal Energy (WAT-SG-62), v3.0
86. SEPA. Undated. Energy position statement
87. SKM. 2012a. Geothermal Energy Potential for Great Britain and Northern Ireland
88. SKM. 2012b. The Geothermal Opportunity for Scotland
89. State of Queensland, 2010. Geothermal Energy Act 2010, Act No. 31 of 2010
90. Stephens, E. 2010. Geothermal Energy in Scotland: Exploring the Territory and Identifying Opportunities, University of St. Andrews
91. The Air Quality (Scotland) Amendment Regulations 2002
92. The Air Quality Standards (Scotland) Regulations 2007. Scottish Statutory Instrument No. 182
93. The Air Quality Standards (Scotland) Regulations 2010
94. The Borehole Sites and Operations Regulations 1995
95. The Coal Authority website http://coal.decc.gov.uk/en/coal/cms/services/licensing/license_apps/license_apps.aspx
96. The Coal Authority. 2012. Minewater Heat Recovery Access Agreement
97. The Coal Authority. 2012. Minewater Heat Recovery Supplementary Access Agreement
98. The Energy Act 2008 (Storage of Carbon Dioxide) (Scotland) Regulations 2011
99. The Environmental Liability (Scotland) Amendment Regulations 2011
100. The Environmental Liability (Scotland) Regulations 2009
101. The Management of Extractive Waste (Scotland) Regulations 2010
102. The Management of Extractive Wastes (Scotland) Regulations 2010
103. The Petroleum Act 1998
104. The Pollution Prevention and Control (Scotland) Regulations 2000 (as amended)
105. The Storage of Carbon Dioxide (Licensing etc) (Scotland) Regulations 2011

106. The Town and Country Planning (Development Management Procedure) (Scotland) Regulations 2008
107. The Town and Country Planning (Development Planning) (Scotland) Regulations 2008
108. The Town and Country Planning (General Permitted Development) (Scotland) Order 1992
109. The Town and Country Planning (Hierarchy of Development) (Scotland) Regulations 2009
110. The Town and Country Planning (Minerals) (Scotland) Regulations 1998.
111. The Town and Country Planning (Scotland) Act 1997
112. The Water Environment (Controlled Activities) (Scotland) Regulations 2011
113. Think Geoenergy website http://thinkgeoenergy.com/archives/9644
114. Town and Country Planning (Scotland) Act 1997 as amended by the Planning etc (Scotland) Act 2006
115. Town and Country Planning Act (Scotland) 1997
116. Transfrontier Shipment of Waste Regulations 1994
117. Water Environment and Water Services (Scotland) Act 2003

Appendix A: Review of Resource Licensing Regimes

Appendix A: Review of Resource Licensing Regimes

A.1 Existing UK licensing regimes which are currently applicable to the commercial exploitation of underground energy sources

A.1.1 Petroleum Licensing in the UK (including 'unconventional' gas resources)

The Department of Energy and Climate Change (DECC) is the government department responsible for energy and issuing Petroleum Licences. The Secretary of State has discretion in the granting of licences, which is exercised to ensure maximum exploitation of national resource. DECC can grant licences that confer exclusive rights to "search and bore for and get" 'petroleum'. Each of these confers such rights over a limited area and for a limited period.

Most licences follow a standard format but DECC is flexible in this regard and will consider adapting new licences to suit special scenarios.

A.1.2 Types of Petroleum Licence

Modern licence types are as follows and Table A.1 gives an overview of the features of each:

- Traditional licence
- Promote licence
- Six-year frontier licence
- Nine-year frontier licence
- Petroleum Exploration and Development Licence (PEDL)
- Supplementary Seismic Survey Licences
- Seaward (Offshore) Exploration Licences

Table A.1 - Types of Petroleum Licence (after DECC)

		Type of licence						
		Seaward (Offshore) Production				**Seaward (Offshore) Exploration**	**Landward (Onshore) Production**	
Terms	**Life cycle of field**	**Traditional Licence / Seaward Production Licence**	**Promote Licence**	**Six-year Frontier Licence**	**Nine-year Frontier Licence**	**Seaward Exploration Licence**	**Petroleum Exploration and Development (PEDL)**	**Supplementary Seismic Survey Licence**
Initial	Exploration	4yrs	4yrs	6yrs	9yrs	For a company that does not need rights to drill or produce. Particularly aimed at seismic contractors who wish to gather data to sell rather than exploit geological resources themselves.	6yrs	For operators of Landward Production Licence who want to shoot a seismic survey right up to the boundary of their licensed area. Lasts for one year and covers a kilometre-wide strip adjacent to the existing Production Licence
Second	Appraisal and Development	4yrs	4yrs	6yrs	6yrs		5yrs	
Third	Production	18yrs	18yrs	18yrs	18yrs		20yrs	
Relinquishment details		Mandatory relinquishment at end of initial term 50%	Mandatory relinquishment at end of initial term 50%	Special mandatory relinquishment of 75% after 3 years with a mandatory relinquishment at the end of the initial term of 50% of the remainder	Special mandatory relinquishment of 75% after six years with a mandatory relinquishment at the end of the initial term of 50% of the remainder		Mandatory relinquishment at end of initial term 50%	
Requirement for proof of technical/ environmental competence		Before offer of licence is made	• After 2 yrs	• Before offer of licence is made	• Before offer of licence is made		Before offer of licence is made	
Comment			• Designed to allow small- and start-up companies a Production Licence first and to attract the necessary operating and financial capacity later. • Annual rental rate is reduced by 90% for two years.	• Designed to allow companies to evaluate large areas with greater materiality for a period, so they can look for a wider range of prospects.	• Designed for the particularly harsh West of Scotland environment.	Cheaper than a Production Licence at flat rate of £2,000/yr	Full name of the Landward Production Licence	

All modern production licences run for the following three successive periods (terms):

- Initial term – may continue into a second term if the agreed work programme has been completed and a minimum amount of acreage has been relinquished;
- Second term – may continue into a third term if a development plan has been approved and all acreage outside the development has been relinquished; and
- Third term – runs for an extended period to allow production

The terms are of different durations, in accordance with the licence type, and there is an escalating annual rental.

The PEDL (Petroleum Exploration & Development Licence) for onshore licensing was introduced in 1996 to reduce bureaucratic burden of issuing a series of licences. Prior to this, the following licensing regimes were used:

Table A.2 Older types of onshore licence (pre-1996)

Time	Type of onshore licence
1950s	Mining Licences
Pre 1984	Exploration Licence Production Licence
1986 – 1992	Exploration Licence (EXL) Appraisal Licence (AL) Development Licence (DL) Production Licence (PL)

A.1.3 Features of Petroleum Licensing in the UK

Rentals

Each licence carries an annual charge, called a rental. Rentals are due each year on the licence anniversary (except pre-20th Round Seaward Production Licences, which were only due in their initial year). Rentals are charged at an escalating rate on each square kilometre the licence covers at that date.

The rentals have dual purpose; to encourage licensees to surrender acreage they don't want to exploit, and to focus licensees on acreage they decide to exploit.

Terms

Seaward (offshore) Production Licences, and Petroleum Exploration and Development Licences, are valid for a sequence of periods, known as ‘terms’. These are designed to comprise the

typical life cycle of a field: exploration, appraisal, production. Each licence will expire automatically at the end of each term, unless the licensee has sufficiently progressed to warrant a chance to move into the next term.

Relinquishments/surrenders

Licensees are entitled to 'determine' (i.e. surrender) a licence, or part of the acreage covered by it, at any time (unless the licence is still in its initial term and the work programme is incomplete). DECC positively encourages the surrender of acreage if the licensee does not intend to work it, and a minimum relinquishment of acreage at the end of the initial term is a condition of most licences.

Multiblock licences

Many licences cover more than one block. 'Multiblock licences' are offshore licences for which the blocks have widely divergent licence groups of companies and are commonly applied to blocks that are scattered geographically.

Landward (onshore) licences and landowners

The Secretary of State issues landward production licences (Petroleum Exploration and Development Licences) under powers granted by the Petroleum Act 1998. They confer the right to search for, bore for and get hydrocarbons, but do not confer any exemption from other legal/regulatory requirements such as:

- any need to gain access rights from landowners
- health and safety regulations
- planning permission from relevant local authorities.

In particular, nothing in part I of the Act confers, or enables the Secretary of State to confer, any right to enter on or interfere with land (see section 9(2) of the Act. However, it should also be noted that section 7(1) of the Act applies the Mines (Working Facilities and Support) Act 1966 in England, Wales and Scotland for the purpose of enabling a licensee to acquire such ancillary rights as may be required for the exercise of the rights granted by the licence.

Licensing rounds

DECC issues licences through competitive licensing rounds. It believes this method yields better quality bids than other methods. Unlike auctions, for instance, licensing rounds do not divert significant sums of money away from exploration work and they give a much better expectation that a licence will be awarded to the bid that promises to optimise exploitation of the UK's petroleum resources.

Onshore and offshore licensing rounds generally take place every year. Out-of-round applications are available in exceptional circumstances.

Other details of licensing in the UK are available at DECC's website:

http://og.decc.gov.uk/en/olgs/cms/licences/licensing_guid/licensing_guid.aspx

A.2 Other Mineral Licences In Great Britain

A.2.1 The Coal Authority

The Coal Authority owns, on behalf of the State, the vast majority of the coal in Great Britain, as well as former coal mines. The Coal Authority is a NDPB (non-departmental public body) sponsored by DECC (Department for Energy and Climate Change), and has specific statutory responsibilities associated with licensing coal mining operations and issues related to past coal mining activities in Great Britain.

Under the Coal Industry Act 1994, the Coal Authority has obligations to consider the implications on existing and future coal mining and the potential for coal bed methane exploitation of any activity which intersects, disturbs or enters any of the Coal Authority's coal interests. Such activities require the prior written authorisation of the Coal Authority in the form of either a Licence, Agreement, or Permit, depending upon the activity to be carried out.

The Coal Authority has introduced a form specific to geothermal development projects that extract heat from minewaters, then a Minewater Heat Recovery Access Agreement is required (see below).

A.2.2 Minewater Heat Recovery Access Agreement (MHRAA)

The Coal Authority grants two types of Minewater Heat Recovery Access Agreement, namely:

- an Access Agreement relating to Minewater Heat Recovery at a single site, with a maximum agreement area of 500 hectares, where all other rights and permissions are in place or applied for; or
- an Access Agreement relating to a larger area, with a maximum size of 2,000 hectares, where the intention is to evaluate the potential for project(s). This type of "blanket" Access Agreement covers the overall area with subsequent Supplemental Agreements required for each borehole site within this overall area.

The MHRAA does not absolve the applicant from obtaining all other necessary rights, including surface access rights, permissions and consents.

The MHRAA covers both open and closed-loop geothermal systems.

Details of the MHRAA can be found on DECC's website:

http://coal.decc.gov.uk/en/coal/cms/services/licensing/license_apps/license_apps.aspx

It is noted that the MHRAA is an access agreement granted by the Coal Authority, largely to protect its assets, and it does not specifically grant a right or licence to the geothermal heat energy itself. This is presumably because the ownership of the heat is legally undefined (see Section 3 - The Ownership of Geothermal Resources in Scotland).

A.3 Existing Licensing Systems in other Countries

Various licensing systems are already in place in different countries and states around the world. The development of these systems has generally been based on the following:

- A legal definition of geothermal energy; and
- Amendment of existing legislation for minerals or water resources to enable licensing; or
- Creation of specific legislation for geothermal energy to enable licensing.

Holroyd and Dagg (2011) carried out an inter-jurisdictional review of geothermal energy legislation and policy for the Government of the Northwest Territories of Canada (NWT) in support of developing a regulatory framework for geothermal energy in the NWT. This review provides a useful summary of some of the legal frameworks that have been put in place in different countries, namely the United States (federal land plus the states of Nevada and California), Canada (province of British Columbia), Australia, New Zealand, Iceland, Italy and Germany. The following sub-sections contain information summarised from Holroyd and Dagg (2011).

The Irish Government has also developed, and is proposing to introduce, specific legislative proposals in respect of geothermal energy. Based on a parliamentary question put to the Irish Minister for Communications, Energy and Natural Resources in October 2012, it is expected that the Geothermal Energy Development Bill will be published in 2013, following publication of the Minerals Development Bill, on which certain aspects of it are based.

A.4 Legal Definitions of Geothermal Resources

Table A.3 summarises the various legal definitions used in the jurisdictions reviewed by Holroyd and Dagg (2011), plus the proposed Irish system, for defining geothermal resource and licensing arrangements.

Table A.3 Legal Definitions for Geothermal Resources in Various Jurisdictions (after Holroyd and Dagg, 2011).

Country	Definition of geothermal resource	Key Features of Licensing and Leasing Arrangements
USA (Federal Lands)	The Geothermal Steam Act of 1970 defines geothermal resources as: "all products of geothermal processes, embracing indigenous steam, hot water and hot brines; (ii) steam and other gases, hot water and hot brines resulting from water, gas, or other fluids artificially introduced into geothermal formations; (iii) heat or other associated energy found in geothermal formations; and (iv) any byproduct derived from them".	• Legislation type: Geothermal specific (The Geothermal Steam Act of 1970 and The Geothermal Production Expansion Act 2010) • Administrative body: Bureau of Land Management (BLM) • BLM / U.S. Forest Service completed a programmatic Environmental Impact Statement (PEIS) in 2008 to identify land for lease sales. • Permits and leases for geothermal energy exploration or development. on BLM or Forest Service land are administrated by the BLM. • Exploration activities include drilling for determination of temperature gradient, for seismic operations and construction related to drilling. • Competitive lease sale every two years, at minimum. A lease is held for 10 years, with up to two five-year extensions. • For direct use projects, land can be nominated by State, Tribal or local Governments. The parcel is posted for 90 days. If expressions of interest from more than one party are received, then the parcel must follow the competitive leasing process. There are nominal fees charged for direct use. • The Geothermal Production Expansion Act 2010 was proposed to amend the Geothermal Steam Act to allow developers to expand geothermal leases to adjacent lands on a non-competitive basis.
California, USA	The California Public Resource Code defines geothermal resources as "the natural heat of the earth, the energy, in whatever form, below the surface of the earth present in, resulting from, or created by, or which may be extracted from, such natural heat, and all minerals in solution or other products obtained from naturally heated fluids, brines, associated gases, and steam, in whatever form, found below the surface of the earth, but excluding oil, hydrocarbon gas or other hydrocarbon substances."	• Legislation type: Geothermal specific (California Environmental Quality Act 63 and The California Public Resource Code) • Administrative body: State Land Commission • Geothermal tenure can be obtained through two methods: competitive bidding leases and prospecting/exploration permits. For competitive bidding leases, the Commission selects land to be made available, and disposes of rights with an auction similar to the federal system. • A Prospecting Permit gives the exclusive right to explore an area for two years with a possible two-year extension. Prospecting Permits can be issued to the first qualified applicant (for lands that have not been selected for competitive public bid). If the permit holder discovers geothermal resources in commercial quantities within their prospecting permit area, they are entitled to a lease for production. • Permits are available for a maximum of four years. The primary term for a lease is 10 years, with extension.

Country	Definition of geothermal resource	Key Features of Licensing and Leasing Arrangements
Nevada, USA	The Nevada Revised Statutes define geothermal resources as “the natural heat of the earth and the energy associated with that natural heat, pressure and all dissolved or entrained minerals that may be obtained from the medium used to transfer that heat, but excluding hydrocarbons and helium.	• Legislation type: Minerals (Nevada Revised Statutes) • The surface owner is the presumed owner of geothermal resources, unless it has otherwise been “reserved or conveyed to another person” under the Stock-Raising Homestead Act of 1916, which granted surface lands to homesteaders, but retained the subsurface rights, or from subsequent sale. • Administrative body: Nevada Commission on Mineral Resources • A permit from the Commission is required to drill or operate a geothermal well. Other aspects of geothermal development are regulated by other state agencies: water appropriation permits for a geothermal flash system are required from the Division of Water Resources, sewage disposal permits are required from the Bureau of Health Protection Services, and water injection permit are required from the Division of Environmental Protection. • Applicants apply for geothermal tenure from the Commission. A permit to drill or operate a geothermal well will be issued if the application is deemed consistent with policies to protect air, water and wildlife. The permit is issued for two years but may be extended upon request.

Country	Definition of geothermal resource	Key Features of Licensing and Leasing Arrangements
British Columbia, Canada	The Geothermal Resources Act of 1982 defines a geothermal resource as “the earth's natural heat and all substances that get added value from it, including steam, water, water vapour and any dissolved substances.” Surface hot springs that have a temperature greater than 80°C at the surface are considered a geothermal resource, but waters less than 80°C are excluded.	• Legislation type: Geothermal specific (The Geothermal Resources Act of 1982) / Petroleum (for disposition of tenure) • Administrative body: Ministry of Energy • The geothermal legislation in B.C. is modelled on the petroleum and natural gas legislation when it comes to disposition of tenure. A company acquires a permit through auction, and there is no minimum bid. • Land that is of interest for geothermal resources is nominated by proponents to the Ministry of Energy. Potential parcels of land undergo a referral process, where the Ministry solicits comments about the parcel from First Nations, local government and other affected agencies. This is to determine existing land uses and environmental sensitivities, and to consult land use plans. From these comments, conditions may be set on the tenure. Tenure availability is posted for six weeks prior to a sealed auction where cash bids or work bids are submitted and tenure is awarded to the highest bidder. • Exploration permits are for one year and can be extended for up to eight years. A permit carries an obligation to explore for geothermal resources, and gives the holder the right to apply for authorization to drill wells. After a well has been drilled and a plan for production submitted, this can be extended to a lease for 20 years with many renewals. • Geoscience exploration (such as drilling a test hole) does not require subsurface rights or land tenure (but does require a geophysical licence).
Australia (general)	Definitions depend on the state or territory within Australia. Some states such as New South Wales, and Tasmania define geothermal resources as a mineral. Other states have specific legislation for geothermal resources, such as Victoria and Queensland where geothermal energy is “heat energy derived from the earth’s natural (subsurface heat).	Geothermal legislation and regulation is unique to each of the states and territories in Australia. The legislation in these six states is described below.

Country	Definition of geothermal resource	Key Features of Licensing and Leasing Arrangements
Queensland, Australia		• Legislation type: Geothermal specific (formerly Geothermal Exploration Act 2004, now Geothermal Energy Act 2011). The latter is intended to be more comprehensive legislation covering both exploration and production and support the goals of the Queensland Renewable Energy Plan. • • The new Act will advance geothermal developments in the State. • Under the Exploration Act, a call for tenders is made and the winner is granted an exploration permit. The bids must include a proposed work program, and evidence that the applicant has the technical and financial resources to carry out the proposed work. The permit holder is required to conduct geothermal exploration and report on the resources to the State. • Other parcels for land can be accessed through application, provided that is it not in a restricted zone. Permits are granted for a maximum of five years and can be renewed for up to three years.
New South Wales, Australia		• Legislation type: Minerals (Mining Act 1992), including geothermal resources as a mineral. • • Geothermal tenure can be issued based on a company's request on first-come, first-served basis, or as a result of tender of designated mineral allocation areas • The state issues an exploration licence that gives the holder the right to explore for the minerals for up to five years (and can be renewed for up to five years). If the exploration proves positive, an assessment lease is issued to evaluate the extent of the resource. Companies must pay a security bond, reach an agreement with the landowner for surface access (including compensation for damages) and demonstrate their financial and technical ability to carry out the project.

Country	Definition of geothermal resource	Key Features of Licensing and Leasing Arrangements
Victoria, Australia		• Legislation type: Geothermal specific (Geothermal Energy Resources Act) for high-end geothermal resources (more than 70°C at a depth of 1000 m) but lower-temperature resources are regulated under existing planning and environmental laws. • • Competing applications are evaluated on the merits of the work program proposed, the benefit for society, and the social and environmental impacts of exploration. • Applications from proponents are accepted for established parcels of land. • Exploration permits (to explore in an area) can last up to 15 years. Retention leases (for discovered but not yet commercial projects) and extraction leases (to produce geothermal resources) can also both last up to 15 years.
South Australia, Australia		• Legislation type: Petroleum / Geothermal specific (Petroleum and Geothermal Act). • • A call for tenders is put out for areas that have a potentially high-value resource. Lower-value resource areas require only an application for exploration. The following types of licences are issued: • exploration licences (five years), retention licences (five-plus years), • production licences, pipeline licences, preliminary and speculative • survey licences (one year) and associated facilities licences. • More than one exploration or production licence may be issued for petroleum and geothermal for the same parcel. An applicant must submit a work bid (commitment to spend a certain amount on exploration) and prove technical and financial resources to complete the work.
Western Australia, Australia		• Legislation type: Petroleum • • The act covers the process for exploration permits (six years), specific prospecting authorities, access authorities, drilling reservations, retention leases (five years) and production licences (21 years). • Different licences may be issued in an area for different resources (geothermal and petroleum).

Country	Definition of geothermal resource	Key Features of Licensing and Leasing Arrangements
Tasmania, Australia		• Legislation type: Minerals (Mineral Resources Development), for resources greater than 70°C and below 1000m. • • Companies must apply for areas that they want to explore and geothermal tenure is granted as a "Special Exploration Licence." The Act provides for a number of different licences, including exploration licences (issued for up to 15 years), retention licences (up to 15 years), prospecting licences and mining leases.
New Zealand	The Resource Management Act (1991) defines geothermal energy as "energy derived or derivable from and produced within the earth by natural heat phenomena; and includes all geothermal water." Geothermal water is defined as "water heated within the earth by natural phenomena to a temperature of 30 degrees Celsius 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."	• Legislation type: Geothermal specific (Resource Management Act came into effect in 1991). Existing geothermal licences distributed under the former Geothermal Energy Act of 1953 were converted to water permits when the Resource Management Act came into effect in 1991. • Administrative body: regional governments • Each region develops a Regional Policy Statement and a Regional Plan as an integrated framework for all development, including geothermal, for example in Waikato, the Regional Policy Statement divides geothermal resources into hydrologically distinct management units known as Geothermal Systems. Systems are classified as Large (up to 350 °C) and Small (less than 100 °C). Systems are also classified for future development potential according to vulnerability of significant features to development and the level of existing use. There are four system categories: Development, Limited Development, Protected, and Research (systems where insufficient information is available to classify). • Proponents interested in a new development file a Resource Consent Application which is assessed by both regional and territorial local authorities. This application must include a System Management Plan that describes how the proponent will manage the reservoir, mitigate surface effects, avoid damage to significant features, and monitor and report data. • When there is more than one operator in a system, protocols must be in place to divide responsibility for system management between the operators. The rights to geothermal tenure are distributed through the allocation of water withdrawals (known as Takes) and Discharges, which are regulated for each category of geothermal system. Takes and discharges are issued for 10 to 35 years.

Country	Definition of geothermal resource	Key Features of Licensing and Leasing Arrangements
Italy	A new law, Legislative Decree, was approved on February 15, 2010, providing rules for exploration and production of geothermal resources in Italy. The general provisions of that law are as follows. 1. Exploration and production of geothermal resources for energy purposes made in Italy, its territorial seas, and on its continental shelves, are considered in the public (national community) interest (importance) and public (national community) utility (usefulness). 2. In accordance with the effects of this law, geothermal resources are defined as being in one of three categories: a. high-enthalpy, characterized by fluid temperatures above 150°C; b. medium-enthalpy, characterized by fluid temperatures between 90°C and 150°C; c. low-enthalpy, with fluid temperatures < 90°C. 3. High-enthalpy geothermal resources, or that which are economically usable for the construction of a geothermal project ensuring certified power output of at least 20MW, are of national interest, as well as those geothermal resources found in marine areas which are economically usable. 4. Medium- and low-enthalpy geothermal resources, or that which is economically usable for the construction of a geothermal project of power less than 20 MW geothermal fluid, are of local interest.	• Legislation type: Geothermal specific (Legislative Decree). Existing geothermal licences distributed under the former Geothermal Energy Act of 1953 were converted to water permits when the Resource Management Act came into effect in 1991. • Administrative body: Ministry of Economic Development in cooperation with the Ministry for the Environment. Administrative functions for the issuance of exploration permits and exploitation concessions have been delegated to the regional governments. Operations and productions are regulated by the National Mining Office for Hydrocarbons and Geothermal, but also delegated to regional authoritative. • Exploration for, and utilization of, thermal water, meaning those waters to be used for therapeutic purposes, are excluded from regulation under this law. • The injection of water and the reinjection of geothermal fluids from the same formations, or at least below aquifers usable in civil or industrial purposes, including marine area, are regionally regulated.
Ireland (proposed)	Geothermal Energy Development Bill will be published in 2013, following publication of the Minerals Development Bill, on which certain aspects of it are based.	• Legislation type: Geothermal specific (proposed Geothermal Energy Development Bill following proposed publication of the Minerals Development Bill). • Administrative body: Communications, Energy and Natural Resources.

Country	Definition of geothermal resource	Key Features of Licensing and Leasing Arrangements
Iceland	Iceland governs geothermal as a "resource" along with all other subsurface resources. A resource is defined as "any element, compound and energy that can be extracted from the Earth, whether in solid, liquid or gaseous form, regardless of the temperature at which they may be found.	• Legislation type: Minerals. • Administrative body: • In Iceland, subsurface resources are owned by the private landowner, while resources on public land are federal property. • Exploration of all subsurface resources are subject to the Act on Survey and Utilization of Ground Resources which allows the government to conduct (or issue a licence to conduct) surveying and prospecting for resources anywhere, on both public and private land. In order to gain a licence for utilization (production), a holder of a survey licence must prove there are adequate resources on the land, and must strike a deal for use with the surface owner for access. Production or use must start within three years of the issuance of the licence or it can be cancelled. • Power plants with a capacity greater than 1 MW or that plan to distribute energy into the grid must gain a licence under the Electricity Act. Large or significant projects are subject to review under the Environmental Impact Assessment Act. Proponents of plants less than 1 MW must submit technical details of their project to the National Energy Authority in Iceland, the body which is also responsible for official monitoring of the resource. • Tenure for development on public land can extend for a maximum of 65 years. • Iceland has developed the Master Plan for Hydro and Geothermal Energy Resources, which provides an overview on the various potential hydro and geothermal energy projects and ranks them based economic feasibility, and environmental and natural heritage impacts. The plan designates resources are available for development, resources to be protected and areas for further investigation. The Master Plan is a strategic environmental assessment of geothermal energy resources and is in the process of being turned into legislation.

Country	Definition of geothermal resource	Key Features of Licensing and Leasing Arrangements
Germany	Geothermal resources are considered a mineral under the federal mining laws. Geothermal heat and geothermal fluids are included under this law.	• Legislation type: Minerals (Mining Act), geothermal energy is considered a federal resource. • Administrative body: Minister of Energy • Any drilling deeper than 100 metres is administered under the Mining Act. • Exploration and production licences are required, and water protection and environmental issues are jointly dealt with by the mining authorities and environmental authorities. • Environmental assessments are required for all geothermal development. • Rights to sub-surface area are allocated by the Minister of Energy without a depth limitation. • A licence for exploration is given for a maximum of five years with the possibility of a three-year extension. If the exploration proves that a viable resource exists, a licence for production is given for up to 20 years.

Appendix B: Review of Planning Documents

Appendix B: Review of Planning Documents

B.1 Review of Existing Planning Legislation (Acts and Regulations)

The following section reviews a range of existing planning legislation in relation to geothermal energy.

B.1.1 The Town and Country Planning (Scotland) Act 1997

The Act is the principal piece of planning legislation governing the use and development of land in Scotland. Certain parts of the act are amended by the Planning etc. (Scotland) Act 2006.

The Act outlines planning procedures and does not make specific reference to energy or geothermal energy.

B.1.2 Planning etc. (Scotland) Act 2006

The Act is the central part of a fundamental and comprehensive reform of the planning system in Scotland, which aims to establish a more inclusive and efficient system to improve community involvement, support the economy, and help it to grow in a sustainable way. The Act amends certain parts of The Town and Country Planning (Scotland) Act 1997, including those related to development planning and development management. These changes came into force on 03 August 2009.

Geothermal energy is not referenced within the Act. Energy is referenced within the Act in the following parts:

Part 2 - Development Plans:

7. 'Form and content of strategic development plan' (4) (d)

This section of the Act refers to the matters, which might be expected to affect the development of the strategic development plan area, including supply of water and energy.

Part 2 - Development Plans:

15. 'Form and content of local development plans' (5) (d)

This section of the Act refers to the matters, which might be expected to affect the development of the local development plan area, including supply of water and energy.

In summary, the Act does not make reference to geothermal energy.

B.1.3 Climate Change (Scotland) Act 2009

An Act to set a target for the year 2050, an interim target for the year 2020, and to provide for annual targets, for the reduction of greenhouse gas emissions; to provide about the giving of advice to the Scottish Ministers relating to climate change; to make further provision about mitigation of and adaptation to climate change; to make provision about energy efficiency; and to make provision about the reduction and recycling of waste.

Chapter 3 of the Act addresses 'Energy Efficiency', including 'promotion of energy efficiency and renewable heat'.
Section 60 confirms that Scottish Ministers must prepare and publish a plan for promoting energy efficiency and setting targets. The Scottish Ministers must from time to time, and within 3 years from the date of publishing, review the plan.

In summary, the Act addresses energy efficiency, but does not specifically address geothermal energy.

B.1.4 The Town and Country Planning (Development Planning) (Scotland) Regulations 2008

The Regulations put in place the regulatory framework required to allow the development planning provisions of the Planning etc. (Scotland) Act 2006 to be commenced. The principal matters dealt with in the Regulations are:

- procedural aspects of preparing Strategic and Local Development Plans;
- development plan examinations;
- development plan schemes;
- action programmes;
- supplementary guidance; and
- designating key agencies (who must cooperate in the preparation of plans).

Energy and geothermal energy are not referenced within the Regulations.

B.1.5 The Town and Country Planning (Development Management Procedure) (Scotland) Regulations 2008

The Regulations put in place the regulatory framework required to allow the development management provisions in Part 3 of the Town and Country Planning (Scotland) Act 1997 as amended by the Planning etc (Scotland) 2006 Act (the 2006 Act) to be commenced.

The Regulations address the changes to development management, including:

- Pre-application consultation with the community,
- New arrangements for the planning authority to notify neighbours of applications;
- New requirements to provide design, or design and access, statements for certain types of planning applications;

Energy and geothermal energy are not referenced within the Regulations.

B.2 Review of Existing Planning Guidance and Advice

This section reviews existing planning guidance and advice in relation to geothermal energy.

B.2.1 Circulars

Circulars contain Scottish Government policy on the implementation of legislation or procedures. One Circular currently relates to renewable energy:

Circular 2/2011 'The Town and Country Planning (General Permitted Development) (Non-Domestic Microgeneration) (Scotland) Amendment Order 2011'

The Circular explains the provisions of the Amendment Order and relates to:

- Ground and water source heat pump pipes
- Solar photo voltaic and solar thermal panels
- Biomass boilers and furnaces
- Anaerobic digestion systems

No Circulars currently relate directly to geothermal energy.

B.2.2 Advice

The Scottish Government provides a range of advice on different subjects and in different forms, including:

- Planning Advice Notes (PAN)
- Guides
- Letters from the Chief Planner
- Design Guidance
- Specific Advice Documents / Sheets

B.2.2.1 Planning Advice Notes (PANs)

Planning Advice Notes (PANs) relating to a range of renewable energy topics have been superseded by Specific Advice Sheets relating to:

- Onshore wind turbines
- Spatial frameworks for wind farms
- Hydro schemes
- Woody biomass
- Landfill gas
- Energy from waste
- Photovoltaic arrays
- Energy storage
- Microgeneration
- Deep geothermal

B.2.2.2 Specific Advice Sheet – Deep Geothermal (March 2012)

The Advice Sheet on Deep Geothermal provides planning advice and information and outlines the following key considerations:

- Suggested areas of focus for planning authorities
- Opportunities within planning processes for Planning Authorities
- Technical information for deep geothermal
- Typical planning considerations in determining planning applications for deep geothermal

Suggested areas of focus for planning authorities

The Advice Sheet provides a range of advice in relation to suggested areas of focus for planning authorities. This includes:

- Collate information on redundant mines
- Consider land use opportunities and constraints to provide indications on where geothermal developments might be located
- Detail criteria to be applied in assessing deep geothermal applications
- Establish protocols and consultees in relation to planning, policy, pre-application and applications for deep geothermal operations

- Identify levels of information to service pre-application discussions and assess applications for deep geothermal
- Ensure planning conditions and agreements for deep geothermal operations are reasonable and proportionate

Opportunities within planning processes for Planning Authorities

The Advice Sheet provides a range of advice in relation to facilitating deep geothermal development, at each stage of the planning process:

- Monitoring and Main Issues Report (MIR)
- Spatial planning
- Draft development plan policy
- Information for planning applications
- Pre-application
- Determination of planning applications

Key opportunities outlined in these planning stages, include:

- Build a database to provide a starting point for assessing potential for deep geothermal operations
- Involve key consultees – British Geological Society, SEPA and SNH
- Determine if deep geothermal possibilities merit consideration as a main issue in the Main Issues Report (MIR)
- Assess scope of using existing brownfield, industrial sites or former collieries
- Determine whether operations can be located near to facilities or areas of high heat demand
- Ensure that policies for deep geothermal cover the potential different scales and types of operations; and design of plant etc and decommissioning
- Develop supporting guidance notes to detail typical information requirements for pre-application discussion and planning applications
- Ensure that advice is given in relation to pre-application consultation
- Ensure developers maximise opportunities to involve communities in pre-application consultation
- Draw upon technical information and typical planning considerations in determining planning applications

Technical information for deep geothermal

The Advice Sheet provides technical information for deep geothermal in relation to:

- Definition
- Basic process
- Suitable locations
- Physical works
- Attributes

Typical planning considerations in determining planning applications for deep geothermal

The Advice Sheet provides information on typical considerations in determining planning applications for deep geothermal, including those relating to:

- Exploratory works
- Noise
- Subsidence
- Waterway pollution
- Seismic activity
- Other planning considerations

In summary, the Advise Sheet on Deep Geothermal outlines key planning considerations in relation to suggested areas of focus for planning authorities; opportunities within planning processes for Planning Authorities; technical information for deep geothermal; and typical planning considerations in determining planning applications for deep geothermal.

The Sheet should provide a basis for planning authorities in Scotland to establish a development planning structure (including Strategic Development Plan and Local Development Plan policy), which relates specifically to geothermal energy; and also establish a development management structure to assist the development of geothermal energy proposals and assess subsequent planning applications.

B.3 Review of Existing Plans and Policies

This section reviews existing plans and policies in relation to geothermal energy.

B.3.1 Scottish Planning Policy (SPP) (2010)

As part of the commitment to proportionate and practical planning policies, the Scottish Government has rationalised national planning policy. The consolidated Scottish Planning Policy (SPP) provides a concise, clear and focused statement of national planning policy.

The SPP sets out:

- the Scottish Government's view of the purpose of planning;
- the core principles for the operation of the system and the objectives for key parts of the system;
- statutory guidance on sustainable development and planning under Section 3E of the Planning etc. (Scotland) Act 2006;
- concise subject planning policies, including the implications for development planning and development management; and
- the Scottish Government's expectations of the intended outcomes of the planning system.

Geothermal energy is not referenced within SPP. Renewable energy is referenced in the following paragraphs.

Paragraph 37:

Decision making in the planning system should:

- contribute to the reduction of greenhouse gas emissions in line with the commitment to reduce emissions by 42% by 2020 and 80% by 2050, contribute to reducing energy consumption and to the development of renewable energy generation opportunities

Paragraph 43:

When designating land for new residential, commercial and industrial development, planning authorities should consider the energy and heat requirements of these new developments. New development should be planned to make use of opportunities for decentralised and local renewable or low carbon sources of heat and power wherever possible.

Renewable Energy is addressed in depth in paragraphs 182 – 195.

Paragraph 182:

The commitment to increase the amount of electricity generated from renewable sources is a vital part of the response to climate change. Renewable energy generation will contribute to more secure and diverse energy supplies and support sustainable economic growth. The current target is for 50% of Scotland's electricity to be generated from renewable sources by 2020 and 11% of heat demand to be met from renewable sources.

Other technologies which may contribute include biomass, solar, energy from waste and landfill gas and offshore wind, wave and tidal power generation. Production of heat and electricity from renewable sources will also make an important contribution both at a domestic scale and through decentralised energy and heat supply systems including district heating and biomass heating plants for businesses, public buildings and community/housing schemes.

Paragraph 184:

Planning authorities should support the development of a diverse range of renewable energy technologies, guide development to appropriate locations and provide clarity on the issues that will be taken into account when specific proposals are assessed. Development plans should support all scales of development associated with the generation of energy and heat from renewable sources, ensuring that an area's renewable energy potential is realised and optimised in a way that takes account of relevant economic, social, environmental and transport issues and maximises benefits.

Paragraph 185:

Planning authorities should ensure that the development plan or supplementary guidance clearly explain the factors that will be taken into account in decision making on all renewable energy generation developments.

Paragraphs 193-195 outlines 'Other Renewable Energy Sources' and refers to biomass plants, hydro-electric schemes, and energy from waste.

In summary, renewable energy is referenced in detail with the SPP. The policy does not make reference to geothermal energy.

B.3.2 National Planning Framework (NPF) 2 (2009)

The National Planning Framework (NPF) is a strategy for the long-term development of Scotland's towns, cities and countryside. The NPF is about shaping Scotland's future and

is concerned with how Scotland develops over the next 20 years and how to make that possible. The NPF identifies key strategic infrastructure needs to ensure that each part of the country can develop to its full potential.

National Planning Framework 2 (NPF2) was published on June 25 2009. It sets the spatial strategy for Scotland's development to 2030, and designates 14 national developments of strategic importance to Scotland. The Planning etc. (Scotland) Act 2006 requires Scottish Ministers to prepare a national planning framework. It also requires planning authorities to take NPF2 into account in development plans and development management decisions.

Key challenges relating to energy are outlined in the several sections of the Framework, including those outlined below.

Paragraphs 25-26:

The European Union has responded by committing to deriving 20% of the energy it uses from renewable sources by 2020. The Scottish Government supports this objective and has in place its own, higher target for electricity generated from renewable sources. It also wants to see continued improvements in energy efficiency; the development of technologies which derive clean energy from fossil fuels; the harnessing of renewable sources of heat; and decentralised energy production, including local heat and power schemes and micro-generation.

Paragraphs 144-165 outline a range of national energy issues including those relating to renewable energy.

Part 3
Energy
25. Tackling climate change and reducing dependence on finite fossil fuels are two of the major global challenges of our time. More than two thirds of the world's Carbon Dioxide (CO 2) emissions are the product of current patterns of energy production and consumption. Growing demand in the expanding Asian economies is raising concerns about the implications for future energy prices and long-term security of supply. Addressing these challenges will demand profound changes in the way we produce, distribute and use energy over the coming decades.

26. The European Union has responded by committing to deriving 20% of the energy it uses from renewable sources by 2020. The Scottish Government supports this objective and has in place its own, higher target for electricity generated from renewable sources. It also wants to see continued improvements in energy efficiency; the development of

technologies which derive clean energy from fossil fuels; the harnessing of renewable sources of heat; and decentralised energy production, including local heat and power schemes and micro-generation.

Part 5 Infrastructure
Renewable Energy

144. While the target of generating 50% of the electricity we use from renewable sources by 2020 is likely to be met, we also need to derive a higher proportion of our energy requirements for heating and transport from renewable sources. In line with EU objectives, the Scottish Government is committed to working towards deriving 20% of total energy use from renewable sources by 2020. It has consulted on a framework for the development and deployment of renewable energy technologies prepared in co-operation with the Forum for Renewable Energy Development in Scotland (FREDS).

145. The Government is committed to establishing Scotland as a leading location for the development of renewable energy technology and an energy exporter over the long term. It is encouraging a mix of renewable energy technologies, with growing contributions from offshore wind, wave, and tidal energy, along with greater use of biomass. The aim of national planning policy is to develop Scotland's renewable energy potential whilst safeguarding the environment and communities

146. The harnessing of renewable sources of energy is effecting a radical change in Scotland's energy economy, and the location of many of these resources means that rural areas are well placed to benefit. As wave, tidal, biomass, solar, hydrogen and offshore wind technologies continue to develop, they will become more competitive and commercially attractive, allowing them to make large contributions to Scotland's energy mix over the next 25 years. Hydro-power and onshore wind are the renewable technologies likely to make the largest contributions initially and biomass should begin to make a significant contribution in the next decade. Given the potential environmental impacts, there is probably limited scope for new large hydro-electric schemes. However, there is significant interest in the development of small-scale schemes on watercourses and canals and the potential to link hydro-power development with pumped storage. Scotland has one of the best environments in the world for wave and tidal generation and marine technologies have the potential to make a major contribution in the longer term. A strategy for the development of marine renewable energy is being prepared

147. The potential of some renewable energy technologies has a strong spatial dimension. The Crown Estate has identified the Moray Firth and a zone to the East of the Firths of Tay and Forth as locations with potential for the development of offshore windfarms. The north and west coasts offer a number of locations with very substantial

potential for harnessing the energy of tidal streams. Further environmental assessment of Scottish coastal waters is being undertaken to inform locational decisions

149. Small-scale renewable energy projects can make a valuable contribution locally. They can play a vital role in supporting the sustainable development of remote rural and island communities in particular. Cumulatively, they can make a significant contribution to the development of a more decentralised pattern of energy generation. Their local environmental effects will need careful management

Baseload Power Stations

151. Given the variable output of some renewable sources of energy, large baseload power stations will have a role to play in maintaining the stability of electricity supply for some time ahead. While important elements of Scotland's existing baseload generating capacity are scheduled to close over the next 10 years, steps are being taken to extend the lives of existing power stations and develop new ones

Heat

163. About 50% of Scotland's energy demand is for heat. While the main energy source for heating is currently gas, Scotland has one of the best climates in Europe for the solar heating of buildings. Higher building standards and improved insulation can substantially reduce heating requirements. There is considerable potential to derive more heat for domestic, business and industrial purposes from sources such as waste and biomass and by using ground, water and air source heat pumps. Better use can also be made of the heat produced by electricity generation, industrial processes and anaerobic digestion. Many of these sources of heat can be harnessed at a domestic, local or community level, but some require larger scale operations. The Scottish Government is committed to helping to build a commercially viable and diverse heat industry and has consulted on a Renewable Heat Action Plan.

Decentralised Production

164. The Government is keen to facilitate the development of a more dispersed pattern of energy generation and supply as part of the response to the climate change challenge. This will involve encouraging community and household heat and power generation, the decentralisation of generation capacity and the development of local heat networks. The efficiency of power stations can be substantially increased by capturing the heat produced by electricity generation to warm our buildings. Advances in technology which allow heat to be transmitted efficiently over longer distances may create scope for developing heat networks based on some of our existing power stations. Harnessing components of the waste stream and other biomass offers the potential to develop new, smaller combined heat and power (CHP) stations close to communities. In some areas, particularly in rural

Scotland, wood or other biomass may provide the most appropriate fuels for local heating schemes. Investment in transmission and distribution networks may be required to facilitate more decentralised patterns of electricity generation.

165. Planning authorities have an important role in facilitating more decentralised patterns of energy generation and supply. They should take account of the potential for developing heat networks when preparing development plans and considering major development proposals.

B.3.3 Structure Plans

Structure Plans set out long term visions and policies for the development of land within local authority areas. They provide a broad framework for Local Plans, which contain more detailed and site specific policies. The two plans together form the Development Plan for a local authority area. Structure Plans are being replaced under the new planning system by Strategic Development Plans (SDPs) for the city regions of Aberdeen, Dundee, Edinburgh and Glasgow.

Five key regions (Aberdeenshire, Clackmannanshire, Fife, Glasgow and West Lothian) have been identified by Scottish Government and the planning assessment process as having good potential to develop geothermal energy schemes. The approved Structure Plans for the five regions are outlined below:

Region	Structure Plan	Status
Aberdeenshire	Aberdeen City and Shire Structure Plan	approved 14 August 2009
Clackmannanshire	Stirling and Clackmannanshire Structure Plan	approved March 2002 with modifications June 2009
Fife	n/a	structure plan superseded by SDP
Glasgow	n/a	structure plan superseded by SDP
West Lothian	Edinburgh and the Lothians Structure Plan	approved June 2004

Key structure plan policy relating to energy for the Aberdeenshire, Clackmannanshire and West Lothian regions is outlined below:

Aberdeen City and Shire Structure Plan

The structure plan sets out sustainable development and climate change targets including for the city region's electricity needs to be met from renewable resources by 2020.
The plan aims to meet such targets through:

- local development plans (and supplementary guidance) will identify areas or technology which can contribute to the supply of renewable energy
- use master planning (and supplementary guidance) to consider the possible scope of combined heat and power schemes to contribute towards using energy more efficiently and in reducing the amount of energy used overall.

The plan does not make specific reference to geothermal energy.

Stirling and Clackmannanshire Structure Plan

Renewable energy policy is outlined in Policy ENV14 as provided by the second Alteration to the Structure Plan (June 2009) and detailed below.

Policy ENV14 – Renewable energy and energy-efficient development
1. In the interests of sustainable development the Councils and the National Park Authority will, subject to conformity with other relevant Structure and Local Plan policies, support: i. developments required for the generation of energy from renewable sources and fuels; and ii. integration of renewable energy generation and utilisation into new developments. 2. Development proposals must demonstrate that energy conservation and efficiency are integral to the design, and to the layout of new buildings.

The plan does not make specific reference to geothermal energy.

Edinburgh and the Lothians Structure Plan

Renewable energy policy is outlined in Policy ENV6 and detailed below.

Policy ENV6 – Renewable Energy
The development of renewable energy resources will be supported where this can be achieved in an environmentally acceptable manner. Local plans should set out the specific criteria against which renewable energy developments will be assessed, including cumulative impact. They should also consider whether it is appropriate to define broad areas of search, or specific sites, suitable for wind or other renewable energy developments.

The plan does not make specific reference to geothermal energy.

B.3.4 Local Plans

Local Plans set out policies to guide development and proposals for specific sites within a local authority area. Local Plans are prepared within the wider, strategic context of the Structure Plan, and together form the Development Plan for a local authority area. Local Plans are to be replaced under the new planning regime by Local Development Plans (LDPs). The adopted Local Plans for the five regions are outlined below:

Region	Local Plan	Status
Aberdeenshire	n/a	local plan superseded by LDP
Clackmannanshire	Clackmannanshire Local Plan	adopted December 2002
Fife	Mid Fife Local Plan Dunfermline and West Fife Local Plan St. Andrews and East Fife Local Plan	adopted January 2012
Glasgow	Glasgow City Plan 2	adopted December 2009
West Lothian	West Lothian Local Plan	adopted 13 January 2009

Key local plan policy relating to energy for each of the Clackmannanshire, Fife, Glasgow, and West Lothian regions is outlined below:

Clackmannanshire Local Plan

Renewable energy and energy efficiency policies are outlined in Policy INF9 and INF10 as detailed below.

Policy INF9 – Renewable Energy Developments (Interim Policy)
Proposals for renewable energy developments will be considered positively provided that they have no significant adverse impact on the built or natural environment. There will be a presumption in favour of smaller renewable energy schemes (less than 25kW peak electrical output) provided that they do not result in any significant harm to the visual amenity, landscape or habitats and do not result in unacceptable noise intrusion. Wind farm developments will not normally be permitted within areas of Green Belt or in any part of the Ochil Hills.

Policy INF10 – Energy Efficiency
Proposed new developments should be designed to maximise energy efficiency while complementing the established character of Clackmannanshire's settlements. The creation of a sheltered micro-climate through the relationship of buildings to each other and by fencing, hedges and shelter belts should be achieved. New development should be situated to maximise shelter afforded by topography. Buildings and windows should be situated and orientated sensitively to maximise passive solar gain.

A Supplementary Advice Note relating to Renewable Energy and Energy Efficiency is planned to be prepared by Clackmannanshire Council.

Mid Fife Local Plan

Policy I1 provides guidance in relation to Renewable Energy as outlined below.

Policy I1 – Renewable Energy
A range of technologies for renewable energy generation, including microrenewables, will be encouraged. Renewable energy developments will be supported provided that: a. there is no significant adverse impact on local communities, the built and/or natural environment, and other uses and activities; b. they provide employment opportunities, particularly diversification of the rural economy; and c. they make use of brownfield or contaminated land, where possible. All proposals will be required to provide detailed information on associated infrastructure required; including roads and grid connections, impact during construction and operational phases of the development, including visual impact, noise, and odour issues; and provisions for the restoration of the site. All new developments should make a positive contribution to environmental quality by incorporating on-site zero and low carbon equipment contributing at least an extra 15% reduction in CO_2 emissions beyond the 2007 Building Regulations carbon dioxide emissions standard. Proposals for combustion of biomass, composting, landfill gas and other technologies will be supported where: d. they make use of brownfield or contaminated land; or e. they provide rural employment opportunities and are consistent with other Development Plan policies. Biomass fuel processing and energy production facilities will be supported where it can be demonstrated that generating efficiency will be enhanced by

co-location and, subject to transportation impact, siting and design. Proposals to abstract geothermal energy from groundwater and other sources will be supported throughout Fife provided that the drilling, engineering and abstraction operations do not:
f. cause unacceptable impacts on the built and natural environment, and residential and other sensitive properties; and
g. do not cause pollution of groundwater.

Proposals for hydro power developments will be supported throughout Fife's river network provided that they do not cause damage to fisheries, fish and other aquatic life within the river catchment. Proposals for using solar panels will be supported provided that they comply with Development Plan policy and Planning Customer Guidelines.

Further renewable energy guidance is provided in the Fife Council Renewable Energy Strategic Project Customer Guidelines (2007), which provides interim guidance until the topic is fully addresses in adopted Plans.

Glasgow City Plan 2

Energy policy is provided by Policy ENV15 as outlined below, which primarily relates to new buildings.

Policy ENV15 – Energy
• All new buildings are required to be designed to maximise their use of passive solar energy from the outset (see policies DES 1: Development Design Principles, DES 2: Sustainable Design and Construction and RES 2: Residential Layouts) and, thereafter, to consider the installation options available for a low and/or zero carbon decentralised energy source, including consideration of a shared resource with a neighbouring development. • All new developments should consider the installation of micro-generating equipment (see Definition) for the small scale production of heat (less than 45 kilowatt thermal capacity) and/or electricity (less than 50 kilowatt electrical capacity) from zero or low carbon source technologies, particularly at a domestic level. • New developments with a total cumulative floorspace of 500sqm or more are required to conform to Scottish Planning Policy (SPP) 6: Renewable Energy (supplemented by guidance to be contained in a new Planning Advice Note (PAN) 84: Reducing Carbon Emissions in new developments). This will require the installation and use of on-site zero and low carbon equipment contributing at least an extra 15% reduction in CO2 emissions beyond the 2007 Building Regulations carbon dioxide emissions standard.

West Lothian Local Plan

A range of renewable energy policy is outlined in the Local Plan including Policy NWR20, as outlined below.

Policy NWR20
The council supports the development of renewable energy schemes provided that the schemes are environmentally acceptable and the criteria set out in this local plan can be met.

B.4 Review of Emerging Plans and Policies

This section reviews existing plans and policies in relation to geothermal energy.

B.4.1 National Planning Framework 3

Planning legislation requires Scottish Ministers to revise the National Planning Framework (NPF) within 5 years of publication. Scottish Ministers have confirmed that work on the

preparation of NPF3 will commence in autumn 2012, focusing strongly on economic recovery and the transition to a low carbon economy.

As development of the NPF3 has not yet commenced, a review of the document has not taken place. As NPF2 however addresses energy and renewable energy in detail, there is scope for the topic of geothermal energy to be included in the emerging NPF3 document.

B.4.2 Strategic Development Plans (SDP)

Strategic Development Plans (SDPs) are the emerging plans for the Aberdeen, Dundee, Edinburgh and Glasgow city-regions. They will set out a vision of how the development of the area could and should occur within a 20 year period, and a spatial strategy of development policies and proposals.

At the time of writing the status of the Strategic Development Plans for the four city regions are:

City Region	Strategic Development Plan	Status
Dundee	TAYplan SDP 2012-2032	SDP approved by Scottish Ministers on 18 June 2012
Glasgow	Glasgow and the Clyde Valley SDP	SDP approved with modifications by Scottish Ministers on 29 May 2012
Edinburgh	SESplan SDP	The Main Issues Report (MIR) and Interim Environmental Report were published in May 2010. The Proposed Plan and Environmental Report were published in November 2011. The SDP is to be submitted to Scottish Ministers in summer/ autumn 2012

City Region	Strategic Development Plan	Status
Aberdeen	Aberdeen City and Shire SDP	The Main Issues Report (MIR) was published in October 2011 and was followed by a consultation period and review of responses. The Strategic Development Plan (SDP) Proposed Plan is being prepared and is expected to be published in November 2012 and followed by a seven week consultation period. The SDP is expected to be approved in June 2014.

The Dundee and Glasgow city-region SDPs have been prepared and approved by Scottish Ministers. An assessment of these plans in terms of energy/ geothermal energy is outlined below.

B.4.2.1 TAYplan Strategic Development Plan (SDP) 2012-2032 (Approved June 2012)

The TAYplan Strategic Development Plan 2012-2032 is the approved SDP for Dundee City, Angus, Perth and Kinross (including part of the Cairngorm National Park) and north Fife. The document was approved by Scottish Ministers on 18 June 2012.

The Energy and Waste/ Resource Management Infrastructure section of the Plan outlines a strategy in relation to the following:

*Energy and waste management infrastructure: Infrastructure for heat and power generation and transmission; and, collection, separation, handling, transfer, processing, resource recovery and disposal of waste. This includes recycling plants, anaerobic waste digesters, energy from waste plants, wind turbines, biomass plants, combined heat and power plants, solar power, hydro electric power plants and similar facilities.

The TAYplan strategy in relation to the above infrastructure is outlined in page 18 of the document as:

This Plan seeks to reduce resource consumption through provision of energy and waste/ resource management infrastructure* in order to contribute to Scottish Government ambitions for the mitigation of and adaptation to climate change and to achieve zero waste. It also aims to contribute towards greater regional energy self-sufficiency.

Land use planning is only one of the regulatory requirements that energy and waste/ resource management operators must consider. This Plan does not provide the locations for energy infrastructure; this role is for Local Development Plans. It sets out a series of locational considerations for all energy and waste/ resource management infrastructure as the impacts and operations of these share similar characteristics.

This Plan ensures consistency between Local Development Plans in fulfilling Scottish Planning Policy requirements to define areas of search for renewable energy infrastructure and it applies this to a wide range of energy and waste/ resource management infrastructure.

It recognises the different scales – property (e.g. micro-renewables or individual waste facilities), community (e.g. district heating and power or local waste facilities) and regional/ national (e.g. national level schemes and waste facilities for wide areas) at which this infrastructure can be provided and both the individual and cumulative contribution that can be made, particularly by community and property scale infrastructure, to Scottish Government objectives for greater decentralisation of heat and energy.

This Plan encourages new strategic scale waste/ resource management infrastructure to be within or close to the Dundee and Perth Core Areas reflecting the proximity of materials and customers for heat and other products.

The TAYplan SDP's strategy in relation to Energy and Waste Resource/ Management Infrastructure is confirmed in Policy 6 of the document, as outlined below.

To deliver a low/ zero carbon future and contribute to meeting Scottish Government energy and waste targets:
A. Local Development Plans should identify areas that are suitable for different forms of renewable heat and electricity infrastructure and for waste/ resource management infrastructure or criteria to support this; including, where appropriate, land for process industries (e.g. the co-location/ proximity of surplus heat producers with heat users). **B.** Beyond community or small scale facilities waste/ resource management infrastructure is most likely to be focussed within or close to the Dundee and/ or Perth Core Areas (identified in Policy 1). **C. Local Development Plans and development proposals should** ensure that all areas of search, allocated sites, routes and decisions on development proposals for energy and waste/ resource management infrastructure have been justified, at a minimum, on the basis of these considerations: • The specific land take requirements associated with the infrastructure technology and associated statutory safety exclusion zones where appropriate; • Waste/ resource management proposals are justified against the Scottish Government's Zero Waste Plan and support the delivery of the waste/resource management hierarchy; • Proximity of resources (e.g. woodland, wind or waste material); and to users/customers, grid connections and distribution networks for the heat, power or physical materials and waste products, where appropriate; • Anticipated effects of construction and operation on air quality, emissions, noise, odour, surface and ground water pollution, drainage, waste disposal, radar installations and flight paths, and, of nuisance impacts on of-site properties; • Sensitivity of landscapes (informed by landscape character assessments and other work), the water environment, biodiversity, geo-diversity, habitats, tourism, recreational access and listed/scheduled buildings and structures; • Impacts of associated new grid connections and distribution or access infrastructure; • Cumulative impacts of the scale and massing of multiple developments, including existing infrastructure; • Impacts upon neighbouring planning authorities (both within and outwith TAYplan); and, • Consistency with the National Planning Framework and its Action Programme.

In summary, the TAYplan SDP outlines a strategy for the region in relation to energy and waste/ resource management infrastructure, and confirms that this infrastructure includes:

- recycling plants
- anaerobic waste digesters
- energy from waste plants
- wind turbines
- biomass plants
- combined heat and power plants
- solar power
- hydro electric power plants
- and similar facilities

The TAYplan SDP's energy and waste/ resource management infrastructure strategy, which includes Policy 6 of the Plan, does not reference geothermal energy or the potential for geothermal energy development.

B.4.2.2 Glasgow and the Clyde Valley Strategic Development Plan (SDP)

The Glasgow and the Clyde Valley Strategic Development Plan is the emerging SDP for Glasgow City, North Lanarkshire, South Lanarkshire, East Dunbartonshire, West Dunbartonshire, East Renfrewshire, Renfrewshire and Inverclyde. The Proposed Plan (June 2011) was approved with modifications by the Scottish Ministers on 29 May 2012.

Diagram 7 of the SDP outlines the Energy component of the Spatial Strategy to 2035, as outlined below:

Decentralised distributed power plants, based on alternative technologies, will be located across the city-region exploiting opportunities to develop biomass, Combined Heat and Power and other forms of renewable energy.

Diagram 8 of the SDP outlines the Spatial Vision and the strategic drivers of change, including:

Energy founded on low carbon sources and systems.

The SDP outlines environmental action in relation to wind energy in section 4.63:

The city-region is characterised by significant potential for onshore wind energy development. Given the context of a low carbon future and the need to decarbonise and green the power grid against a context of emissions reduction targets, yet also seeking to protect important natural environments, the SDP adopts the approach of defining search areas for wind farm developments.

Strategy Support Measure 12 outlines the strategy of the SDP in relation to energy and a paradigm shift, as outlined below.

Energy and a new low carbon paradigm
In order to achieve a paradigm shift in energy generation and consumption to meet a low or decarbonised future, a structured approach 'Energy – Carbon Masterplanning' could be adopted in Local Development Plans when taking forward the core components of the SDS model, including Community Growth Areas (Diagram 10). This approach needs a partnership with power utility companies to develop tailored energy solutions for the communities concerned.

In summary, the Glasgow and the Clyde Valley SDP outlines a spatial strategy in relation to energy, which includes distributed power plants, based on alternative technologies exploiting opportunities to develop biomass, Combined Heat and Power and other forms of renewable energy. The SDP also adopts the approach of defining search areas for wind farm development.

The SDP outlines a strategy in relation a range of potential energy development, but does not specifically reference geothermal energy.

B.4.2.3 SESplan Strategic Development Plan (SDP)

The Main Issues Report (MIR) and Interim Environmental Report were published in May 2010. The Proposed Plan and Environmental Report were published in November 2011. The Proposed Plan is to be submitted to Scottish Ministers in autumn 2012.

Energy is addressed in the Proposed Plan in paragraphs 123-124 and policy 10 as outlined below. The Proposed Plan does not make specific reference to geothermal energy.

Policy 10 – Sustainable Energy Technologies
The Strategic Development Plan seeks to promote sustainable energy sources. Local Development Plans will: a. Support the future development and associated infrastructure requirements of Longannet and Cockenzie power stations in relation to their role as non-nuclear, baseload capacity generators, Energy Park Fife at Methil, and developments connected with offshore renewable energy in Leith and Rosyth; and b. Set a framework for the encouragement of renewable energy proposals, taking into account relevant economic, social, environmental and transport considerations.

B.4.2.4 Aberdeen City and Shire Strategic Development Plan (SDP)

The Main Issues Report (MIR) was published in October 2011 and was followed by a consultation period and review of responses. The proposed Strategic Development Plan (SDP) is being prepared and is expected to be published in November 2012 and followed by a seven week consultation period.

Renewable energy proposals are set out in the MIR in section 8 (Proposals). The MIR does not make specific reference to geothermal energy.

B.4.3 Local Development Plans (LDP)

Local Development Plans (LDPs) are the emerging plans for local authority areas in Scotland. They should be adopted within 2 years of the approval of the relevant SDP and must be replaced at least every 5 years. They will contain a spatial strategy of policies and proposals as to the development and use of land for a period up to year 10 from adoption.

At the time of writing Local Development Plans for the following local authority areas in Scotland have been adopted:

Local Development Plan	Adopted
Aberdeen LDP	29 February 2012
Highland-wide LDP	05 April 2012

B.4.3.1 Aberdeen Local Development Plan (LDP)

The 'Using Resources Sustainably – Renewable and Low Carbon Energy Developments' section of the LDP outlines the Council's strategy in relation to renewable energy:

The development of all types of renewable heat and energy generating technologies, on all scales, is supported in principle. A positive approach to renewable development will help to meet the Scottish Governments target for 80% of Scotland's electricity to be generated from renewable sources by 2020 and 11% of heat demand to be met by renewable sources.

Much of the onshore renewable energy capacity in the North East of Scotland will come from large scale developments, such as wind farms, which are more difficult to accommodate in urban locations than in more rural locations. However, there will be a range of energy technologies that are more suited to urban locations. These range from single wind or hydro turbines through to gas or biomass fired Combined Heat and Power systems, ground source heat pumps, and devices which can be mounted on existing buildings (some of which are classed as permitted development). Supplementary

Guidance on appropriate technologies will be provided through masterplans and the forthcoming low carbon city energy strategy.

In summary, the Aberdeen LDP addresses a range of renewable energy issues including waste resource, energy from waste, combined heat and power, low carbon energy and wind energy. The LDP does not specifically reference geothermal energy as part of the renewable energy strategy.

B.4.3.2 Highland-wide Local Development Plan (LDP)

The 'Sustainable Development and Climate Change – Renewable Energy Developments' section of the LDP outlines the Council's strategy in relation to onshore wind, hydro electric power, biomass, energy from waste, landfill gas and marine renewable. Policy 67 'Renewable Energy Development' is the key LDP policy in relation to renewable energy. Key requirements outlined in the policy include:

Renewable energy development proposals should be well related to the source of the primary renewable resources that are needed for their operation. The Council will also consider:

- the contribution of the proposed development towards meeting renewable energy generation targets; and
- any positive or negative effects it is likely to have on the local and national economy; and will assess proposals against other policies of the development plan, the Highland Renewable Energy Strategy and Planning Guidelines and have regard to any other material considerations, including proposals able to demonstrate significant benefits including by making effective use of existing and proposed infrastructure or facilities.

In summary, the Highland-wide LDP outlines energy considerations and policy in relation to wind energy, hydro electric power, biomass, energy from waste, landfill gas and marine renewable. The LDP does not outline guidance and policy specifically in relation to geothermal energy.

B.4.3.3 Emerging Local Development Plans (LDPs)

In addition to the two Local Development Plans which have been adopted, further LDPs are emerging and include those for areas with potential for geothermal energy development such as Clackmannanshire, Fife, Glasgow, and West Lothian.

Clackmannanshire LDP

The Main Issues Report (MIR), Monitoring Statement, Environment Report, Site Assessment Report and Open Space Framework were open to public consultation during

January – March 2011. Chapter 4 of the MIR outlines a vision and key issues in relation to climate change. The MIR does not make specific reference to geothermal energy.

Comments and representations on these documents are being currently considered by Clackmannanshire Council and the Local Development Plan (LDP) Proposed Plan is being prepared for public consultation.

Fife LDP

Early information gathering stages have taken place. The first formal stage will be the preparation and publication of the Monitoring Statement and Main Issues Report (MIR) which is scheduled to commence in autumn 2012.

The Council are establishing a 'Local Development Plan Exchange', which will be an informal liaison group to exchange ideas throughout the Plan's preparation.

Glasgow LDP

The Main Issues Report (MIR), Monitoring Statement (MS) and Interim Environment Report (IER) were published in October 2011 for consultation. Issue 1.2 and Option 1.2 of the MIR relate to renewable energy and the potential for wind and biomass installations in the city and other renewable options where appropriate, as outlined below.

Option 1.2 – Renewable Energy
Option 1.2 A (Preferred Option) Investigate the potential for wind and biomass installations in the City, and other renewable options where appropriate, to operate effectively and contribute towards reducing man-made greenhouse gas emissions attributable to the City. If appropriate, deliver new policy to establish the circumstances in which such installations would be acceptable, supported by detailed supplementary guidance. This Option is Preferred because … It provides a positive basis for assessing the potential of renewable energy in the City to contribute to the delivery of the targets set out in the Climate Change Act.

Issue 1.3 and Option 1.3 of the MIR relate to low carbon heating/ combined heat and power. This section of the MIR states the Council's preferred option in relation to ground-source heat, as outlined below:

The Council is also keen to progress investigative work on the potential of ground-source heat for district heating. This provides relatively low grade heat found at relatively shallow depths within the earth's crust, derived from solar warming. The British Geological Survey

(BGS) have identified significant potential in ground water in bedrock aquifers and superficial deposits, such as shales, for ground-source heat across much of the City. Geological modelling work, currently ongoing, should help identify which areas may offer most promise in this respect. This resource has the potential to contribute to the Scottish Government's target of meeting 11% of heat demand from renewable sources by 2020.

Should ground source heat prove an attractive proposition, the Council will bring forward new policy to ensure its potential is utilised, and to address any issues relating to design, environmental impacts, etc. This is likely to be in the form of supplementary guidance.

Option 1.3 – Local Renewable/ Low Carbon Sources of Heat and Power
Option 1.3 A (Preferred Option) Revise existing policy to, wherever possible, require major new development to be designed to connect to existing or planned district heating networks and/or to develop opportunities for decentralised and local renewable (such as ground-source heat) or low carbon sources of heat and power to meet their own, on-site, needs and potentially those of others in a local heat network. Produce supplementary guidance to set out the detail of how this might be done. Identify the East End Zone as a priority for investment in infrastructure necessary to deliver local renewable or low carbon sources of heat and power. Ensure new development in the zone is designed to accommodate CHP/DH infrastructure. Investigate further the implications of retro-fitting the other 4 zones with the necessary infrastructure to deliver heat to homes and businesses. This Option is Preferred because … It would provide for the planning of new development to make use of opportunities for decentralised and local renewable or low carbon sources of heat and power wherever possible. It provides for an assessment of the significant potential for use of ground source heat as a source of local renewable heat and hot water. It identifies a priority project in the East End, whilst recognising that further work will be required to take this forward and to examine options for delivery elsewhere in the City.

The MIR proposes a new Key Policy relating to the sustainable use of resources, as outlined below.

KP2 – Energy and Related Developments
New key policy outlining what is/is not likely to be supported – detail in Sustainable Resources Supplementary Guidance. Likely to set out the Councils' approach to promoting renewable energy production and low carbon heating/combined heat and power (see issues 1.2 and 1.3) and lighting (issue 1.6).

The MIR proposes that the key policies of the LDP are supported by Supplementary Guidance (SG) including SG relating to district heating, as outlined below.

Topic	Action
Combined Heat and Power/District Heating	**New** guidance to reflect outcomes of consideration of opportunities for low carbon sources of heat and power (issues 1.3, possibly issue 1.4).

The comments received on the MIR, MS and IER have been analysed and this will inform the development of the Local Development Plan (LDP) Proposed Plan during 2012-2013. Glasgow City Council will also engage with key agencies and stakeholders to identify and confirm the key policies that will inform the LDP. The LDP is expected to be adopted in 2014.

West Lothian LDP

The Main Issues Report (MIR) and Environmental Report are scheduled to be developed during 2012, with consultation on the reports taking place during 2012-2013. The publication of formal responses to the MIR is scheduled to take place in May 2013. The LDP is expected to be adopted in 2015.

Table B.1 Planning Assessment – Summary Table

Existing Planning Legislation (Acts and Regulations)

Document Type	Document Title	Review of Planning Document (Summary)	Reference to Energy (✓ - X - n/a)	Reference to Geothermal (✓ - X - n/a)	Identification of Required Changes	Recommendation of Actions
Act	Town and Country Planning Act (Scotland) 1997	The Act outlines planning procedures and does not make reference to energy or geothermal energy.	X	X	Specific reference to geothermal energy.	The application of a change to the Act, through a provision inserted into the Act relating to energy and geothermal energy.
Act	Planning etc. (Scotland) Act 2006	Geothermal energy is not referenced within the Act. Energy is referenced within the Act as per below: Part 2 - Development Plans: 7. 'Form and content of strategic development plan' (4) (d) Refers to the matters, which might be expected to affect the development of the strategic development plan area, including supply of water and energy. Part 2 - Development Plans: 15. 'Form and content of local development plans' (5) (d) Refers to matters, which might be expected to affect the development of the local development plan area, including supply of water and energy.	✓	X	The Act refers to the supply of energy in Strategic Development Plan and Local Development Plan areas. A required change to the Act includes specific reference to geothermal energy.	The application of a change to the Act, through a provision inserted into the Act, which relates specifically to geothermal energy and the requirement for Strategic Development Planning Authorities and Local Development Planning Authorities to acknowledge the potential for geothermal energy development, when preparing their Plans and considering how development in their area should and could occur.
Act	Climate Change (Scotland) Act 2009	The Act addresses energy efficiency, but does not specifically address geothermal energy.	✓	X	The Act addresses the promotion of energy efficiency and renewable heat. A required change to the Act includes the specific reference to geothermal energy.	The application of a change to the Act, through a provision inserted into the Act relating specifically to geothermal energy.
Regulations	The Town and Country Planning (Development Planning) (Scotland) Regulations 2008	Energy or geothermal energy not referenced within the regulations.	X	X	The Regulations put in place the regulatory framework required to allow the development planning provisions of the Planning etc. (Scotland) Act 2006 to be commenced. Energy and geothermal energy	No required changes to the Regulations have been identified.

Document Type	Document Title	Review of Planning Document (Summary)	Reference to Energy (✓ - X - n/a)	Reference to Geothermal (✓ - X - n/a)	Identification of Required Changes	Recommendation of Actions
					are not referenced within the Regulations. It is not within the scope of the regulations to address energy and geothermal energy. No required changes have therefore been identified.	
Regulations	The Town and Country Planning (Development Management Procedure) (Scotland) Regulations 2008	Energy or geothermal energy not referenced within the regulations.	X	X	The Regulations put in place the regulatory framework required to allow the development management provisions in Part 3 of the Town and Country Planning (Scotland) Act 1997 as amended by the Planning etc (Scotland) 2006 Act (the 2006 Act) to be commenced. Energy and geothermal energy are not referenced within the Regulations. It is not within the scope of the regulations to address energy and geothermal energy. No required changes have therefore been identified.	No required changes to the Regulations have been identified.

Guidance and Advice

Document Type	Document Title	Review of Planning Document (Summary)	Reference to Energy (✓ - X - n/a)	Reference to Geothermal (✓ - X - n/a)	Identification of Required Changes	Recommendation of Actions
Circular	Circular 2/2011 The Town and Country Planning (General Permitted Development) (Non-Domestic Microgeneration) (Scotland) Amendment Order 2011	The Circular explains the provisions of the Amendment Order and relates to: • Ground and water source heat pump pipes • Solar photo voltaic and solar thermal panels • Biomass boilers and furnaces • Anaerobic digestion systems	✓	X	n/a No Circulars currently relate directly to geothermal energy. No required changes to Circulars have been identified.	n/a No Circulars currently relate directly to geothermal energy. No required changes to Circulars have been identified.
Planning Advice Note (PAN)	n/a	Planning Advice Notes (PANs) relating to a range of renewable energy topics have been superseded by Specific Advice Sheets relating to: • Onshore wind turbines • Spatial frameworks for wind farms • Hyrdo schemes • Woody biomass • Landfill gas • Energy from waste • Photovoltaic arrays • Energy storage • Microgeneration • Deep geothermal	n/a	n/a	n/a Planning Advice Notes (PANs) relating to a range of renewable energy topics have been superseded by Specific Advice Sheets. The Sheets include one relating specifically to deep geothermal. No required changes to PANs have been identified.	n/a No required changes to PANs have been identified.
Specific Advice Sheet	Deep Geothermal (March 2012)	The Advise Sheet on Deep Geothermal outlines key planning considerations in relation to: • suggested areas of focus for planning authorities • opportunities within planning processes for Planning Authorities • technical information for	✓	✓	The Advice Sheet provides thorough advice in relation to the planning and assessing of deep geothermal energy developments. No specific required changes have been identified.	Ensure both Strategic Development Planning Authorities (SDPA) and Local Planning Authorities address in the first instance • the suggested areas of focus for

Document Type	Document Title	Review of Planning Document (Summary)	Reference to Energy (✓ - X - n/a)	Reference to Geothermal (✓ - X - n/a)	Identification of Required Changes	Recommendation of Actions
		deep geothermal • typical planning considerations in determining planning applications for deep geothermal. The Sheet should provide a basis for planning authorities in Scotland to establish a development planning structure (including Strategic Development Plan and Local Development Plan policy), which relates specifically to geothermal energy; and also establish a development management structure to assist the development of geothermal energy proposals and assess subsequent planning applications.				planning authorities; and • the opportunities within planning processes This will assist the establishment of geothermal energy within plans and policies. In relation to the emerging Strategic Development Plans (SDPs) and Local Development Plans (LDPs), Strategic and Local Planning Authorities should determine if geothermal energy possibilities merit consideration as a main issue in the Main Issues Report (MIR).

Existing Policy and Plans

Document Type	Document Title	Review of Planning Document (Summary)	Reference to Energy (✓ - X - n/a)	Reference to Geothermal (✓ - X - n/a)	Identification of Required Changes	Recommendation of Actions
Policy (National)	Scottish Planning Policy (SPP) (2010)	Geothermal energy is not referenced within the Policy. Renewable energy is referenced in the following paragraphs 37 and 43. Renewable Energy is addressed in depth in paragraphs 182 – 195. Paragraph 182 The commitment to increase the amount of electricity generated from renewable sources is a vital part of the response to climate change. Renewable energy generation will contribute to more secure and diverse energy supplies and support sustainable economic growth. The current target is for 50% of Scotland's electricity to be generated from renewable sources by 2020 and 11% of heat demand to be met from renewable sources. Other technologies which may contribute include biomass, solar, energy from waste and landfill gas and offshore wind, wave and tidal power generation. Production of heat and electricity from renewable sources will also make an important contribution both at a domestic scale and through decentralised energy and heat supply systems including district heating and biomass heating plants for businesses, public buildings and community/housing schemes. Paragraph 184 Planning authorities should support the development of a diverse range of renewable energy technologies, guide development to appropriate locations and provide clarity on the issues that will be taken into account when specific proposals are assessed. Development plans should support all	✓	X	Scottish Planning Policy (SPP) makes reference to renewable energy, and a range of technologies which can contribute to renewable energy generation, including biomass, solar, energy from waste etc. A required change to SPP is specific reference to geothermal energy as a renewable energy technology to be supported by local authorities to respond to energy generation requirements and climate change targets.	It is recommended that Scottish Planning Policy (SPP) is amended and updated to include specific reference to geothermal energy. Reference should be included within paragraphs 182-195, which relates to renewable energy. Geothermal energy should be highlighted as a renewable energy technology to be supported by local authorities to respond to energy generation requirements and climate change targets.

Document Type	Document Title	Review of Planning Document (Summary)	Reference to Energy (✓ - X - n/a)	Reference to Geothermal (✓ - X - n/a)	Identification of Required Changes	Recommendation of Actions
		scales of development associated with the generation of energy and heat from renewable sources, ensuring that an area's renewable energy potential is realised and optimised in a way that takes account of relevant economic, social, environmental and transport issues and maximises benefits. Paragraph 185 Planning authorities should ensure that the development plan or supplementary guidance clearly explain the factors that will be taken into account in decision making on all renewable energy generation developments. Paragraphs 193-195 outlines 'Other Renewable Energy Sources' and refers to biomass plants, hydro-electric schemes, and energy from waste.				
Policy (National)	National Planning Framework 2 (NPF2) (2009)	Key challenges relating to energy are outlined in paragraphs 25-26 The European Union has responded by committing to deriving 20% of the energy it uses from renewable sources by 2020. The Scottish Government supports this objective and has in place its own, higher target for electricity generated from renewable sources. It also wants to see continued improvements in energy efficiency; the development of technologies which derive clean energy from fossil fuels; the harnessing of renewable sources of heat; and decentralised energy production, including local heat and power schemes and micro-generation. Paragraphs 144-165 outlines a range of national energy issues including those relating to renewable energy:	✓	X	National Planning Framework (NPF) 2 highlights challenges and issues relating to energy and renewable energy. A required change to the Framework is the specific reference to geothermal energy as a source of energy generation.	It is recommended that National Planning Framework (NPF) is amended by means of the emerging NPF3. Geothermal energy should be highlighted within NPF3 as a source of energy generation which can contribute to national energy use from renewable sources targets.

Document Type	Document Title	Review of Planning Document (Summary)	Reference to Energy (✓ - X - n/a)	Reference to Geothermal (✓ - X - n/a)	Identification of Required Changes	Recommendation of Actions
		Renewable energy Paragraph 144 While the target of generating 50% of the electricity we use from renewable sources by 2020 is likely to be met, we also need to derive a higher proportion of our energy requirements for heating and transport from renewable sources. In line with EU objectives, the Scottish Government is committed to working towards deriving 20% of total energy use from renewable sources by 2020. It has consulted on a framework for the development and deployment of renewable energy technologies prepared in co-operation with the Forum for Renewable Energy Development in Scotland (FREDS). Paragraph 145 The aim of national planning policy is to develop Scotland's renewable energy potential whilst safeguarding the environment and communities.				
Structure Plan	Aberdeen City and Shire Structure Plan	The structure plan sets out sustainable development and climate change targets including for the city region's electricity needs to be met from renewable resources by 2020. The plan does not make specific reference to geothermal energy.	✓	X	A required change to the plan is the specific reference to geothermal energy.	The plan will be superseded by the Aberdeen City and Shire Strategic Development Plan (SDP), which is currently being prepared and expected to be published in November 2012 followed by a seven week consultation period. Consideration should be given to geothermal energy during the development of the SDP.
Structure Plan	Stirling and Clackmannanshire Structure Plan	Renewable energy policy is outlined in Policy ENV14 - Renewable energy and energy-efficient development. The plan does not make specific reference to geothermal energy.	✓	X	A required change to the plan is the specific reference to geothermal energy.	The plan will be replaced by the Stirling Local Development Plan (LDP) and the Clackmannanshire Local Development Plan (LDP). The Stirling LDP proposed

Document Type	Document Title	Review of Planning Document (Summary)	Reference to Energy (✓ - X - n/a)	Reference to Geothermal (✓ - X - n/a)	Identification of Required Changes	Recommendation of Actions
						plan is due to be published in October 2012. The Clackmannanshire LDP proposed plan is currently being prepared and a period of consultation will take place following the publication of the document. Consideration should be given to geothermal energy during the development of the LDPs.
Structure Plan	Edinburgh and the Lothians Structure Plan	Renewable energy policy is outlined in Policy ENV6. The plan does not make specific reference to geothermal energy.	✓	X	A required change to the plan is the specific reference to geothermal energy.	The plan will be superseded by the Edinburgh and the Lothians Strategic Development Plan (SDP), which is expected to be submitted to Scottish Ministers in summer/ autumn 2012. Consideration should be given to geothermal energy during the development of the SDP.
Local Plan	Clackmannanshire Local Plan	Renewable energy and energy efficiency policies are outlined in Policy INF9 and INF10 as detailed below. A Supplementary Advice Note relating to Renewable Energy and Energy Efficiency is planned to be prepared by Clackmannanshire Council. The plan does not make specific reference to geothermal energy.	✓	X	A required change to the plan is the specific reference to geothermal energy.	The local plan will be replaced by the Clackmannanshire Local Development Plan (LDP). Consideration should be given to geothermal energy during the development of the LDP.
Local Plan	Mid Fife Local Plan	Policy I1 provides guidance in relation to Renewable Energy. The plan does not make specific reference to geothermal energy. Dunfermline and West Fife Local Plan St. Andrews and East Fife Local Plan	✓	X	A required change to the plan is the specific reference to geothermal energy.	The local plan will be replaced by the Fife Local Development Plan (LDP). Consideration should be given to geothermal energy during the development of the LDP.
Local Plan	Glasgow City Plan 2	Energy policy is provided by Policy ENV15, which primarily relates to new buildings. The plan does not make specific reference to geothermal	✓	X	A required change to the plan is the specific reference to geothermal energy.	The city plan will be replaced by the Glasgow Local Development Plan (LDP) (City Plan 3).

Document Type	Document Title	Review of Planning Document (Summary)	Reference to Energy (✓ - X - n/a)	Reference to Geothermal (✓ - X - n/a)	Identification of Required Changes	Recommendation of Actions
		energy.				Consideration should be given to geothermal energy during the development of the LDP.
Local Plan	West Lothian Local Plan	A range of renewable energy policy is outlined in the Local Plan including Policy NWR20. The plan does not make specific reference to geothermal energy.	✓	X	A required change to the plan is the specific reference to geothermal energy.	The local plan will be replaced by the West Lothian Local Development Plan (LDP). Consideration should be given to geothermal energy during the development of the LDP.

Emerging Policy and Plans

Document Type	Document Title	Review of Planning Document (Summary)	Reference to Energy (✓ - X - n/a)	Reference to Geothermal (✓ - X - n/a)	Identification of Required Changes	Recommendation of Actions
Policy (National)	National Planning Framework 3 (NPF3)	NPF3 to be developed by the Scottish Government from autumn 2012.	n/a	n/a	n/a	Liaison with NPF3 planning team to ensure the consideration of geothermal energy during the development of the Framework.
Strategic Development Plan (SDP)	TAYplan SDP	The TAYplan SDP outlines a strategy for the region in relation to energy and waste/ resource management infrastructure, and confirms that this infrastructure includes: - recycling plants - anaerobic waste digesters - energy from waste plants - wind turbines - biomass plants - combined heat and power plants - solar power - hydro electric power plants - and similar facilities The TAYplan SDP's energy and waste/ resource management infrastructure strategy, which includes Policy 6 of the Plan, does not reference geothermal energy or the potential for geothermal energy development.	✓	X	Specific reference in the TAYplan SDP's energy and waste/ resource management infrastructure section, including Policy 6, to geothermal energy and the potential for geothermal energy development.	
Strategic Development Plan (SDP)	Glasgow and the Clyde Valley SDP	The Glasgow and the Clyde Valley SDP outlines a spatial strategy in relation to energy, which includes distributed power plants, based on alternative technologies exploiting opportunities to develop biomass, Combined Heat and Power and other forms of renewable energy. The SDP also adopts the approach of defining search areas for wind farm development. The SDP outlines a strategy in relation a range of potential energy development, but does not specifically reference geothermal energy.	✓	X	Specific reference in the Glasgow and the Clyde Valley SDP's energy and a paradigm shift section to geothermal energy.	
Strategic	SESplan SDP	The SESplan SDP is to be submitted	✓	X	Specific reference to	

Document Type	Document Title	Review of Planning Document (Summary)	Reference to Energy (✓ - X - n/a)	Reference to Geothermal (✓ - X - n/a)	Identification of Required Changes	Recommendation of Actions
Development Plan (SDP)		to Scottish Ministers in summer/ autumn 2012. The plan does not make specific reference to geothermal energy.			geothermal energy and the potential for geothermal energy development is required in the emerging SDP.	
Strategic Development Plan (SDP)	Aberdeen City and Shire SDP	The Main Issues Report (MIR) was published in October 2011 and was followed by a consultation period and review of responses. The proposed Strategic Development Plan (SDP) is being prepared and is expected to be published in November 2012 and followed by a seven week consultation period.	✓	X	Specific reference to geothermal energy and the potential for geothermal energy development is required in the emerging SDP.	
Local Development Plan (LDP)	Aberdeen City LDP	The Aberdeen LDP addresses a range of renewable energy issues including energy from waste, combined heat and power, low carbon energy and wind energy. The LDP does not specifically reference geothermal energy as part of the renewable energy strategy.	✓	X	Specific reference to geothermal energy and the potential for geothermal energy development is required in the LDP.	Supplementary Guidance should be prepared to provide detailed guidance on the topic.
Local Development Plan (LDP)	Highland-wide LDP	The Highland-wide LDP outlines energy considerations and policy in relation to wind energy, hydro electric power, biomass, energy from waste, landfill gas and marine renewable. The LDP does not outline guidance and policy specifically in relation to geothermal energy.	✓	X	Specific reference to geothermal energy and the potential for geothermal energy development is required in the LDP.	Supplementary Guidance should be prepared to provide detailed guidance on the topic.
Local Development Plan (LDP)	Clackmannanshire LDP	The adopted local plan will be replaced by the Clackmannanshire Local Development Plan (LDP). Chapter 4 of the Main Issues Report (MIR) outlines a vision and key issues in relation to climate change. The MIR does not make specific reference to geothermal energy. The LDP Proposed Plan is being prepared for public consultation.	X	X	Specific reference to geothermal energy and the potential for geothermal energy development is required in the emerging LDP.	During the development of the LDP, consideration should be given to geothermal energy development. Supplementary Guidance should be prepared to provide detailed guidance on the topic.
Local Development Plan (LDP)	Fife LDP	The adopted local plan will be replaced by the Fife Local Development Plan (LDP).	X	X	Specific reference to geothermal energy and the potential for geothermal energy development is required in the emerging LDP.	The potential for geothermal energy development should be highlighted through the Local Development Plan Exchange liaison group. Consideration should be given to geothermal

Document Type	Document Title	Review of Planning Document (Summary)	Reference to Energy (✓ - X - n/a)	Reference to Geothermal (✓ - X - n/a)	Identification of Required Changes	Recommendation of Actions
						energy development as a Main Issue in the Main Issues Report (MIR) of the emerging LDP. This should be supported by specific policy and Supplementary Guidance relating to the topic.
Local Development Plan (LDP)	Glasgow LDP	The adopted city plan will be replaced by the Glasgow Local Development Plan (LDP) (City Plan 3). The Main Issues Report (MIR) outlines issues relating to renewable energy and local heat and power. The MIR proposes a new key policy 'KP2 – Energy and Related Developments', which addresses these issues and may be supported by Supplementary Guidance. The LDP Proposed Plan is being prepared for public consultation.	✓	✓	Specific reference to geothermal energy and the potential for geothermal energy development is required in the emerging LDP.	Consideration of geothermal energy development should be addressed through new key policy KP2 and Supplementary Guidance.
Local Development Plan (LDP)	West Lothian LDP	The adopted local plan will be replaced by the West Lothian Local Development Plan (LDP).	X	X	Specific reference to geothermal energy and the potential for geothermal energy development is required in the emerging LDP.	Consideration should be given to geothermal energy development as a Main Issue in the Main Issues Report (MIR) of the emerging LDP. This should be supported by specific policy and Supplementary Guidance relating to the topic.

Appendix C: Summary of Main Outcomes from the Stakeholder Workshop

Appendix C: Summary of Main Outcomes from the Stakeholder Workshop

The Project Stakeholder Workshop was held on the 31 October 2012 at the offices of the British Geological Survey in Edinburgh. The following organisations participated in the stakeholder workshop:

Aberdeenshire Council

British Geological Survey

City of Edinburgh Council

Cluff Geothermal

Cornwall Council

Edinburgh Centre for Carbon Innovation

Fife Council

Geoserve Solutions

Geothermal Engineering

Glasgow Caledonian University

Glasgow City Council

GT Energy

Health & Safety Executive

Midlothian Council

North Ayrshire Council

Scottish and Southern Energy

Scottish Enterprise

Scottish Power

Scottish Renewables

Semple Fraser LLP

Scottish Environment Protection Agency

Tait Enterprise Development Limited

The Coal Authority

The James Hutton Institute

The Scottish Government

University of Glasgow

University of St Andrews

West Lothian Council

The following sections provide a summary of the main outcomes of each workshop session.

C1 Session 1 - Legal and Resource Licensing

Is a specific resource licensing regime required for deep geothermal energy resources?

- It was considered that 'deep' geothermal energy should be a state resource and therefore should be legally defined as such through a statutory resource licensing regime, to control and administrate geothermal development and protect the resource. There are parallels with the development of the oil and gas industry in the UK.
- It is considered that the deep geothermal industry in the UK is currently at the 'research and design' or 'demonstrator' stage and that the lack of a specific resource licensing regime has not significantly hindered the development of the deep geothermal industry to date (geological risk is currently the primary concern for the proposed deep geothermal projects in Cornwall). However, the industry is currently developing and evolving and for it to continue to do so, a specific resource licensing regime is considered to be required in the near future.
- It was postulated that, based on the current rate of development of the deep geothermal industry, resource licensing will be required in the near future (say within 18 to 24 months) and therefore action is required immediately in order to put this in place. Timing for getting legislation produced or amended is critical and action may be required prior to the end of the 2012/2013 financial year (end of March 2013).
- When the industry has approached UK Government energy regulators (DECC) in the recent past to request that a licensing system be put in place, feedback had been that it would be difficult for DECC to justify spending on developing a licensing system for such a fledgling industry but they would anticipate introducing licensing if the industry develops significantly.
- Future investment in deep geothermal energy projects is unlikely to happen unless specific developments are licensed. Introduction of a resource licensing regime now, early in the evolution of the deep geothermal industry would assist in shaping the future industry. The geothermal resource needs to be managed sustainably through licensing and regulation.
- There is a need for a strategic heat resource strategy as per the water resource strategy.

Potential licensing regimes for deep geothermal energy

- It was considered that any License must be site specific to protect the geothermal asset and the environment. Site specific modelling is required as part of the licensing process to demonstrate no significant impact upon adjacent reserves ('significance' would need to be defined or determined).
- It was considered that due to the wide range of geothermal heat resources that different licensing regimes should apply depending on the geological source of the heat and or the depth. It was also suggested that truly 'deep' geothermal be defined as resources at greater than 1000m depth. Licensing may also be required for resources at 'moderate' depth, say 100m to 1000m deep.
- Water, either groundwater or injected water, is generally the medium through which heat is extracted in a geothermal development (excluding closed-loop systems which tend to be relatively shallow) and therefore licensing is likely to relate to abstraction and re-injection of water ('discharge').
- It was considered that existing groundwater abstraction licences are inadequate as they are primarily aimed at environmental protection, as opposed to heat resource protection, and do not specifically consider geothermal heat extraction.

Existing Licensing Regimes in the UK

- In England and Wales geothermal is currently dealt mainly through the groundwater abstraction licensing regime administered by the Environment Agency (EA). Experience from one developer suggested the following process is being followed:
    a. The developer goes to the EA and gives exact details about the borehole saying how much land area they consider will be effected by the development;
    b. The EA awards an abstraction license on this basis;
    c. The developer constructs the borehole and then determines whether they need larger or smaller area (based on borehole testing);
    d. The license size is then amended to suit the actual area required; and
- A similar groundwater abstraction licensing regime exists in Scotland.
- It is noted that abstraction licenses are primarily in place for environmental protection rather than geothermal resource protection.
- It is also noted that abstraction licenses does not take account of third-party land interests, other than other groundwater abstraction licences.
- For geothermal developments affecting the interests of The Coal Authority, require a license for access to or through existing coal mine workings and / or coal reserves.

- In addition, The Coal Authority has developed a system of “Heat Access Agreements” to license abstraction of geothermal heat from coal mine workings and / or coal reserves.
- It was suggested that geothermal resource licensing should potentially be similar to petroleum resource licensing, and include:
    a. Separate licenses to explore and produce;
    b. Environmental / hydraulic fracturing controls could be included;
    c. Third-party land interests, that could potentially be affected by directional drilling or heat extraction, could be considered; and
    d. Could include a royalties mechanism for if the resource becomes valuable in the future.

Existing Licensing Regimes in Other Countries

- Various licensing systems are in place in different countries around the world.
- The Irish Geothermal Licensing regime is a potential model for a UK or Scottish licensing regime:
    a. Deep geothermal is defined as greater than 1km in Ireland;
    b. From the Irish example, the state should take ownership of the resource;
    c. The Irish Legal System is very similar to the UK;
    d. Compulsory purchase of all land rights below 1km (zero value); and
    e. Anyone with existing interests below 1km to declare them (none to date)
- There were similar workshops in Ireland 2 to 3 years ago so Scotland is currently perhaps 2 to 3 years behind Ireland in developing a resource licensing regime.
- There may be lessons to be learned from the existing resource licensing regimes in other countries.

Opportunities for introducing a resource licensing system

- It was considered that there is now an opportunity to re-introduce proposals for resource licensing to DECC because:
    a. There is a greater and growing interest and momentum in the geothermal sector;
    b. Licensing in Ireland was apparently developed in liaison with DECC;
    c. There is new licensing for hydraulic fracturing for the developing shale gas industry;
    d. The Scottish Government could potentially lobby DECC to introduce licensing, potentially following the Irish example;

e. It is considered that DECC may be receptive to such an approach as they recognise the need for resource licensing; and

f. There is a potential opportunity for amendment of the Electricity Market Reform Bill to include resource licensing but timing is critical for introducing any amendments through the Westminster Parliament.

C2 Session 2 - Environmental Legislation and Permitting

Adequacy of existing environmental permitting

- It is considered that environmental permitting is currently adequate for addressing geothermal energy developments.
- It was stated that clear guidance on the application of relevant environmental legislation would be beneficial for potential developers of geothermal energy projects.
- It is considered that more specific reference to “deep geothermal” or “geothermal” in environmental legislation would provide clarity and assist potential developers of geothermal energy projects.
- Environmental regulators positioned to ensure resources are protected on a holistic basis
- Contamination between aquifers is a key risk.
- Regulation should be linked to heat energy and not just water quality

Application of environmental permitting and regulations

- Water quality could actually be improved by geothermal heat extraction treating extracted water before discharge or re-injection, including removing iron from ferrous-rich mine waters. The Coal Authority has a pilot scheme for pumping, treating and extracting heat from mine water discharge at Dawden in Co. Durham.
- Concern was expressed over potential standards for re-injection of groundwater following heat extraction, potentially to Drinking Water Standards (DWSs) and / or Environmental Quality Standards (EQSs) which could be overly onerous and may inhibit development of geothermal resources, particularly those in former mining areas.
- The area of ‘development’ refers to surface not sub-surface, geothermal developments could effect a wider area than the surface compound. Under existing EIA regulations, there is a threshold is an apparently arbitrary 1 hectare on the surface site area before an EIA is required. It is noted that drilling compounds may be deliberately kept below this threshold to avoid the need for an EIA.

SEPA's viewpoint on existing regulation

- Deep geothermal developments are likely to require a Controlled Activities Regulations (CAR) license under existing regulation.
- Of particular concern to SEPA is that geothermal (or other) borehole construction is "fit for purpose" and does not cause cross-contamination between different aquifers that may overlie each other. NB - confidential: there is likely to be incoming control on drilling of boreholes to prevent cross-contamination between aquifers in CAR GBR3.
- There was a review of CAR licensing for shale gas issues and Coal Bed Methane (CBM, 'coal gasification').
- SEPA have produced practical guidance for hydraulic fracturing / stimulation.
- Change in temperature is defined as a potential pollutant under the Water Framework Directive

Issues around stimulation for development geothermal resources

- For potential stimulation of geothermal resources:
    a. The meaning needs to be defined and terminology carefully defined and used;
    b. Stimulation will induce seismic events but the scale of these will vary dependent on the situation; and
    c. Has been carried out extensively in Scotland, particularly Scottish highlands to enhance bedrock permeability for public water supply.
- It was stated that we should wary about aligning geothermal with shale gas extraction for licensing and regulation because there are significant differences between hot water for geothermal and flammable gas and the risks are therefore different
- It was acknowledged that both the public and politicians are concerned about hydraulic fracturing and that public perception and communication from industry is essential.
- SEPA reinforced the need to engage the public and that the geothermal industry needs to speak as one voice in relation to these issues which could be perceived to be of concern.

There was some debate within the wider group on the potential interaction of different regulatory licensing and regulatory regimes, for example the potential conflict between say a geothermal project (currently controlled by CAR licensing) and say a coal gasification project (controlled by Petroleum licensing). It is considered that this potential conflict or uncertainty is due to a lack of a specific resource licensing regime for geothermal energy and that such potential conflicts need to be addressed in development of such a regime.

C3 Session 3 - Planning

What are seen as the Primary potential Planning barriers and what options exist within planning to improve opportunities for deep geothermal energy developments and what options exist to improve opportunities?

- Planning Authorities need to have the expertise to assess a geothermal application. It is a significant responsibility for the Planning Authority and potentially significant pressure for the individual planner concerned.
- Current planning applications can only be dealt with under existing planning policies. The current perceived lack of clarity and specific advice could potentially lead to delay in determination of applications.
- It is noted that in assessing planning applications there will be a predictable range of issues with which Planners are familiar, including noise and traffic. The primary impacts are generally during drilling, including potentially 24 hours a day (dependent on the type and scale of the development). There is generally a low visual impact.
- To deal with primary planning impacts in terms of policy context requires strategic level support. There is currently a perceived lack of policy coverage.
- Uncertainty was expressed over whether Planning is required at the exploration stage for drilling boreholes.
- Hydraulic fracturing is not required for developing the majority of deep geothermal resources and would only be relevant for the deepest ‘enhanced’ systems which would be limited in number and extent. Hydraulic fracturing required for deep geothermal energy development is very different to for shale gas extraction but this distinction needs to be defined and clarified.
- Developers want planning certainty supported by primary Government policy.

What are the primary potential planning policy interventions or actions that could be put into place at national / local level?

- The Scottish Government could consider changes to planning policy in relation to promoting geothermal energy, for example there could be a presumption in favour of deep geothermal developments which would give greater planning certainty.
- Amending planning policy to give greater planning certainty for deep geothermal energy developments would assist in de-risking and therefore encourage investment.
- It was considered that deep geothermal energy should be included in the review of National Planning Framework (NPF) and Scottish Planning Policy (SPP) and national planning guidance.

- The Scottish Government have commenced the development of a NPF3 document. Comments are currently being accepted by the Government via an on-line proposals form. The closing date for submission of completed forms is Friday 14 December 2012.
- The Scottish Government have also commenced the development of a revised SPP. Comments are currently being accepted by the Government via an on-line priorities for change form. The closing date for the submission of completed forms is Friday 11 January 2013.
- The NPF and the SPP could potentially contain information about resource availability and heat mapping. Deep geothermal resources could also be linked to District Heating.
- There are potential parallels with the way Coal Bed Methane (CBM) was incorporated into Planning.

Are there realisable scales of deep geothermal that could be factored into development planning, policies or development management advice?

- It was considered that deep geothermal should be included in Local Development Plans (LDPs) that are currently being prepared, or as they are reviewed in the future, dependent on the current status of the review cycle.
- Geological information on the locations of potential deep geothermal resources could be included in development plans in map form to show their spatial distribution with the Planning Authority area.
- Under the Climate Change Act, LDP's are required to include for provision of on-site renewable energy, and this could include deep geothermal energy.
- It was recognised that there are various scales of geothermal energy developments at various depths, from shallow (tens of metres) to deep (thousands of metres), and the planning regime needs to take account of this.
- Within Scotland, only a limited number of Planning Authorities are likely to be involved in a particular scale of geothermal energy developments.
- It was suggested that supplementary specific planning guidance (SPG) for deep geothermal should be developed.
- The 2016 Zero Carbon Building policy will potentially influence geothermal developer actions and choices

Are there any resources / tools or other actions that could assist planning authorities in supporting deep geothermal opportunities and effectively dealing with any applications submitted?

- So that the requirement for deep geothermal energy developments can be assessed, amended planning advice should include links to demand i.e. heat demand and heat source (including geothermal resources) maps for Planning Authority areas.
- There should be information about the industry and its development prior to planning consideration including what the benefits are.
- The Scottish Government Planning should facilitate and have responsibility for developing advice and guidance but this should be developed jointly with other stakeholders, including representatives of the geothermal development industry.
- There is a requirement for Planners to have access to knowledge through training and CPD to make informed decisions in relation to deep geothermal energy developments.
- Planners need to ask the right questions rather than request significant amounts of information from applicant due to lack of experience of such projects
    a. Unfamiliarity amongst planners; and
    b. Should ensure the first Planning Authority to go through geothermal planning application are supported wherever possible by the Scottish Government.
- It was noted that pre-application consultation is not required for geothermal projectsbut should be considered.
- Planning applications for large-scale deep geothermal projects should be phased to allow a staged approach to exploration and development.
- Can use planning to build public confidence
- Planning facilitation of district heating and heat stores could actually encourage development of geothermal energy as a heat source
- Need to communicate positive messages to the public regarding deep geothermal energy, including that heat generated is used locally (as opposed to generating electricity to be used elsewhere) and it is a cheaper, low-carbon heat and reliable source of heat energy.
- Heat pumps could be used to balance a district heat network?

C4 Costs, Financing and Benefits

Is the ROC / RHI level likely to encourage interest in the Deep Geothermal / Mine water Sector?

- ROC is considered a good support mechanism if pitched at right level and that a ROC level of 4 to 5 would be reasonable for deep geothermal as an emerging technology that would provide baseload.

- It was questioned whether geothermal, as a developing market, would realistically be able to take advantage of the current UK level of support of 2 ROCs, as it is likely that much activity will take place post-2013 (with support reducing to 1.8 ROCs in 2017).
- ROCs should be compatible with other countries, particularly European countries (including Germany), as UK projects are competing in the international investment market for geothermal development. Schemes in other countries are also generally backed by exploration risk insurance.
- There is currently no FiT available for electricity produced using geothermal energy.
- It is considered that the 5p/kWh RHI currently proposed by DECC could make the business case for deep geothermal heat developments (>500m depth).
- It is anticipated that after say 100MW of installed development the RHI could reduce as the cost of equity reduces.
- It was suggested that there should potentially be different tariffs for different geothermal technologies / applications, i.e. for GSHPs, mine workings, HSA/hydrothermal and HDR.

What needs to happen to encourage increased drilling activity?

- The new UK Green Investment Bank is keen on investing in deep geothermal but only at the low risk stage, i.e. would invest in the second well once the resource has been proved but not the initial exploratory well.
- From one developer's experience, deep geothermal development funding is typically a 50:50 equity to bank debt split. Equity investors require a 20% return.
- Deep geothermal Geothermal development attractive to pensions funds and other long-term investors due to long life - the resource potentially lasts for 100s of years.
- Success rates for deep geothermal electricity generation schemes can be as low as 10 to 40%, however, heat-only schemes are much less risky.
- Heat-only schemes can have a 100% success rate if managed properly and this has been the case in Germany:
    e. Therefore projects in Germany have not required risk insurance;
    f. Expected to run 250-300 years; and
    g. Very attractive for pension funds and other long-term investors.
- Geothermal heat is much less risky than deep geothermal electricity production and should be targeted first:
    a. 10 to 40% success rate for deep geothermal electricity production compared to up to 100% for deep geothermal heat;

   b. Deep geothermal heat developments are not as deep so less of a technical challenge, easier to predict the resource, reduced drilling costs, etc;
   c. Deep geothermal heat developments require groundwater abstraction at only ~85°C and 50 litre/sec , compared to ~150°C and 150 litre/sec for deep geothermal electricity production; and
   d. But needs to be near to end use heat loads.

- Consideration should be given to a Scottish deep geothermal exploration risk insurance scheme similar to the schemes that are in place in most other countries that are developing geothermal resources.
   a. The Scottish Government would underwrite the exploration risks;
   b. Potentially this may not perceived as “State Aid” (to be confirmed);
   c. It could potentially be funded or part-funded by banks (e.g. German Development Bank scheme); and
   d. The Scottish Government has no grant funding
- Holland has a 80% deep geothermal exploration risk insurance scheme with the aim being to promote drilling activity.
- As the geothermal resource evidence base increases the potential risks will be reduced and it will be easier to get private funding. Geothermal risks can also be reduced by good practice.
- In the UK, it is currently not possible to get any grant funding and revenue support (FiT/ROC), unlike some other European countries many of which also have higher levels of revenue support.
- One developer considered that grant aid really only assists the particular development but that revenue support can encourage the whole industry.

What financial interventions in other areas might stimulate development activity in Scotland?

- Community and Renewable Energy Scheme (CARES) that is available for wind, hydro and heat could be rolled out for deep geothermal.
- Public financing for deep geothermal exploration means geological information is available to others to build a knowledge base, reduce risks and encourage private investment.
- Some other countries have Nationalised drilling companies for drilling wells, for example in Kenya.
- If using public financing and direct involvement then how and when the development is handed to the private sector.

- There was some debate in the workshop regarding who is best paced to develop District Heating Networks (DHNs), private utilities companies (e.g. E-On have increased their District Heating development team 10 fold) or Local Authorities (e.g. Manchester City Council have allowed for facilitation of development of district heating in Planning etc).
- Scotland's petroleum drilling resources and expertise could potentially be re-tasked into deep geothermal drilling as part of the switch from fossil fuels to renewable energy sources to stimulate finance and reduce costs in the deep geothermal sector.

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