

Title: Underground Access Rights clauses in 2014 Infrastructure Bill – impact on deep geothermal activities IA No: DECC0179 Lead department or agency: Department of Energy and Climate Change (DECC) Other departments or agencies: None	Impact Assessment (IA)			
	Date: 22 September 2014			
	Stage: Final			
	Source of intervention: Domestic			
	Type of measure: EANCB Validation			
Contact for enquiries: Ajay Dhillon 03000 682922				
Summary: Intervention and Options				RPC: RPC Opinion Status

Cost of Preferred (or more likely) Option				
Total Net Present Value	Business Net Present Value	Net cost to business per year (EANCB in 2009 prices)	In scope of One-In, Two-Out?	Measure qualifies as
£41.01 million	£1.42 million	-£0.518 ¹ million	Yes	OUT


What is the problem under consideration? Why is government intervention necessary? Operators wishing to extract geothermal energy have to negotiate with landowners for underground access rights. This is a time consuming, uncertain and potentially costly process. If a landowner refuses access, that project cannot continue.

What are the policy objectives and the intended effects? To simplify the existing procedure for underground access, whilst ensuring that key features, such as payment and notification, are retained. Nothing in the proposed measures will have any effect on other regulatory or legal provisions including the licencing regime (water abstraction), planning permission, health and safety regulation and environmental regulation. A parallel impact assessment considers the impact on oil and gas projects of the proposed changes.
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What policy options have been considered, including any alternatives to regulation? Please justify preferred option (further details in Evidence Base) Non-regulatory options are limited as the issue is founded in law. The preferred option is to grant underground access (below 300 metres) for the extraction of these energy resources in Great Britain with a concordant voluntarily payment from those companies to communities located above the underground drilling. Three payment options have been considered: no payment (Option 1); payment to individual landowners (Option 2); and community payment (Option 3). Community payment is significantly less costly to administer than individual payments; it removes the costs of individual negotiations and removes the potential for delay to and/or cancellation of projects if access is refused. The proposed measure (Option 3) includes a reserve power to introduce payment in statute if industry reneges on their voluntary agreement. Voluntary payment is preferable to a payment in statute as this gives a greater degree of flexibility of its administration and is thus more adaptable to meet changing needs. However, for the purpose of the Impact Assessment voluntary payment options are assumed to be the same as those in statute. All payment options include a concordant notification system.

Will the policy be reviewed? It will not be reviewed. If applicable, set review date: Year						
Does implementation go beyond minimum EU requirements?				N/A		
Are any of these organisations in scope? If Micros not exempted set out reason in Evidence Base.	Micro: No	< 20: Yes	Small: Yes	Medium: Yes	Large: Yes	
What is the CO ₂ equivalent change in greenhouse gas emissions? (Million tonnes CO ₂ equivalent)			Traded: N/A		Non-traded: -0.89m	

I have read the Impact Assessment and I am satisfied that, given the available evidence, it represents a reasonable view of the likely costs, benefits and impact of the leading options.

Signed by the responsible Minister:  Date: 25/09/2014

¹ This is based upon a conservative estimate of two deep geothermal projects proceeding please see the OITO section for a more detailed explanation. The EANCB is assessed over a 29 year assessment period covering the years 2015–2043.

Summary: Analysis & Evidence

Policy Option 1

Description: No compensation

FULL ECONOMIC ASSESSMENT

Price Base Year 2014	PV Base Year 2014	Time Period Years 29 ² /37	Net Benefit (Present Value (PV)) (£m)		
			Low: 10.81	High: £ 70.86	Best Estimate: 41.13

COSTS (£m)	Total Transition (Constant Price) Years		Average Annual (excl. Transition) (Constant Price)	Total Cost (Present Value)
Low	0	0	1.3	33.1
High	0		4.8	135.1
Best Estimate	0		2.9	83.2

Description and scale of key monetised costs by 'main affected groups'

The key costs for each policy option are the estimated capital and operating costs associated with the additional deep geothermal plants brought forward by the policy options. These costs are all borne by business.

Other key non-monetised costs by 'main affected groups'

None.

BENEFITS (£m)	Total Transition (Constant Price) Years		Average Annual (excl. Transition) (Constant Price)	Total Benefit (Present Value)
Low	0	0	2.7	43.9
High	0		11.3	205.9
Best Estimate	0		6.7	124.3

Description and scale of key monetised benefits by 'main affected groups'

There are benefits to business from the production of heat from deep geothermal projects due to the avoided capital, operating and gas input fuel costs of using a gas boiler to instead supply heat to a heat network. There are also benefits to society from carbon emission reductions and improved air quality impacts which have also been monetised.

The total NPV is estimated by estimating the incremental costs of: capital, operating and input fuel of a typical deep geothermal plant over a gas boiler. Also included in the total NPV are the carbon and air quality impacts.

Other key non-monetised benefits by 'main affected groups'

None.

Key assumptions/sensitivities/risks	Discount rate (%)
The key assumption for deep geothermal is on the number of projects which are likely to proceed over the assessment period. The central NPV assumes 6 projects being constructed and commencing the supply of heat whilst the low and high NPV scenarios have 2 and 10 projects being brought forward, respectively. A range is presented above based on different levels of deployment.	3.5

BUSINESS ASSESSMENT (Option 1)

Direct impact on business (Equivalent Annual) £m:			In scope of OITO?	Measure qualifies as
Costs: 1.4	Benefits: 1.9	Net: -0.520	Yes	OUT

² Under the low NPV scenario two projects are projected to be brought forward with one commencing construction in 2015 and the other in 2016. The low NPV is assessed over a 29 year assessment period covering the years 2015–2043. Whilst for the central and high NPV's a 37 year (2015–2051) assessment period is used as projects are projected to commence construction and produce heat over a longer time horizon.

Summary: Analysis & Evidence

Policy Option 2

Description: Individual compensation

FULL ECONOMIC ASSESSMENT

Price Base Year 2014	PV Base Year 2014	Time Period Years 29/37	Net Benefit (Present Value (PV)) (£m)		
			Low: 10.55	High: 69.74	Best Estimate: 40.45

COSTS (£m)	Total Transition (Constant Price) Years		Average Annual (excl. Transition) (Constant Price)	Total Cost (Present Value)
Low	0	0	1.3	33.3
High	0		4.8	136.2
Best Estimate	0		2.9	83.9

Description and scale of key monetised costs by 'main affected groups'

The key costs for each policy option are the estimated capital and operating costs associated with the additional deep geothermal plants brought forward by the policy options. The administration costs of the individual compensation scheme are also included. These costs are all borne by business.

Other key non-monetised costs by 'main affected groups'

None.

BENEFITS (£m)	Total Transition (Constant Price) Years		Average Annual (excl. Transition) (Constant Price)	Total Benefit (Present Value)
Low	0	0	2.7	43.9
High	0		11.3	205.9
Best Estimate	0		6.7	124.3

Description and scale of key monetised benefits by 'main affected groups'

There are benefits to business from the production of heat from deep geothermal projects due to the avoided capital, operating and gas input fuel costs of using a gas boiler to instead supply heat to a heat network. There are also benefits to society from carbon emission reductions and improved air quality impacts which have also been monetised.

The total NPV is estimated by estimating the incremental costs of: capital, operating and input fuel of a typical deep geothermal plant over a gas boiler. Also included in the total NPV are the carbon and air quality impacts.

Other key non-monetised benefits by 'main affected groups'

None.

Key assumptions/sensitivities/risks	Discount rate (%)
The key assumption for deep geothermal is on the number of projects which are likely to proceed over the assessment period. The central NPV assumes 6 projects being constructed and commencing the supply of heat whilst the low and high NPV scenarios have 2 and 10 projects being brought forward, respectively. A range is presented above based on different levels of deployment.	3.5

BUSINESS ASSESSMENT (Option 2)

Direct impact on business (Equivalent Annual) £m:			In scope of OITO?	Measure qualifies as
Costs: 1.4	Benefits: 1.9	Net: -0.509	Yes	OUT

Summary: Analysis & Evidence

Policy Option 3

Description: Community compensation

FULL ECONOMIC ASSESSMENT

Price Base Year 2014	PV Base Year 2014	Time Period Years 29/37	Net Benefit (Present Value (PV)) (£m)		
			Low: 10.76	High: 70.65	Best Estimate: 41.01

COSTS (£m)	Total Transition (Constant Price) Years		Average Annual (excl. Transition) (Constant Price)	Total Cost (Present Value)
Low	0	0	1.3	33.1
High	0		4.8	135.3
Best Estimate	0		2.9	83.3

Description and scale of key monetised costs by 'main affected groups'

The key costs for each policy option are the estimated capital and operating costs associated with the additional deep geothermal plants brought forward by the policy options. The administration costs of the community compensation scheme are also included. These costs are all borne by business.

Other key non-monetised costs by 'main affected groups'

None.

BENEFITS (£m)	Total Transition (Constant Price) Years		Average Annual (excl. Transition) (Constant Price)	Total Benefit (Present Value)
Low	0	0	2.7	43.9
High	0		11.3	205.9
Best Estimate	0		6.7	124.3

Description and scale of key monetised benefits by 'main affected groups'

There are benefits to business from the production of heat from deep geothermal projects due to the avoided capital, operating and gas input fuel costs of using a gas boiler to instead supply heat to a heat network. There are also benefits to society from carbon emission reductions and improved air quality impacts which have also been monetised.

The total NPV is estimated by estimating the incremental costs of: capital, operating and input fuel of a typical deep geothermal plant over a gas boiler. Also included in the total NPV are the carbon and air quality impacts.

Other key non-monetised benefits by 'main affected groups'

None.

Key assumptions/sensitivities/risks	Discount rate (%)
The key assumption for deep geothermal is on the number of projects which are likely to proceed over the assessment period. The central NPV assumes 6 projects being constructed and commencing the supply of heat whilst the low and high NPV scenarios have 2 and 10 projects being brought forward, respectively. A range is presented above based on different levels of deployment.	3.5

BUSINESS ASSESSMENT (Option 3)

Direct impact on business (Equivalent Annual) £m:			In scope of OITO?	Measure qualifies as
Costs: 1.4	Benefits: 1.9	Net: -0.518	Yes	OUT

Evidence Base

The discussion below considers the impact of options for changing underground access rights to explore for and develop deep geothermal energy.

Problem under Consideration

The Government's heat strategy *The Future of Heating: Meeting the challenge* (March 2013; https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/190149/16_04-DECC-The_Future_of_Heating_Accessible-10.pdf) identified the development of district heating networks as an important part of the transition to low carbon heating and identified deep geothermal as a potential heat source for those networks.

Deep geothermal resources can be located across large areas. Two wells are needed to sustainably harness geothermal energy (one for abstraction and one for re-injection). Although these wells will be a few metres apart at the surface, at depth the wells may extend up to 2 km horizontally. The total area of underground land accessed by the wells could have numerous landowners, particularly in densely populated areas. In the case of deep geothermal projects located in cities, according to industry this would affect an average of 3,000 landowners per project under whose land drilling might take place.

In the UK, landowners still own the land beneath their homes and landowners have legislative and common law rights to be notified and compensated if anyone wishes to access that land, even if the access occurs underground and is unlikely to cause them any inconvenience. We believe that underground horizontal drilling at the depths relevant for geothermal would not have any negative impacts on the landowner's use of the land – the main risks that could have any perceived impact on landowners and others living above horizontal underground drilling are outlined on pages 15–17 of our consultation document (see

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/313576/Consultation_on_Underground_Drilling_Access_final_web_version.pdf).

The geothermal industry faces similar underground access issues as the petroleum industry. However, where petroleum operators may refer a case to court to secure access there is no equivalent existing legal route for a geothermal operator to gain underground access in this way, should a landowner refuse access. Without a legislative change it is unlikely that the proposed geothermal schemes (for example, heat schemes in Manchester, Newcastle, North Tyneside, Crewe and Stoke) will be able to proceed. Geothermal heat plants will always need to be located where there is sufficient heat demand, particularly in or near cities and other urban areas.

Rationale for intervention

The purpose of this policy is to overcome developmental barriers to the geothermal industry from the existing process in gaining access to underground land. This is intended to give investors greater certainty and help to enable the industry to become established.

It is believed that, so far as underground development goes, the existing system does not strike the right balance between the legitimate interests and concerns of landowners and the benefits to the community and nation at large of permitting development, where the development is otherwise acceptable in planning and environmental terms. Since the impact on the landowner from underground drilling is negligible, and broader issues of concern about the environmental and other impacts of the proposed activities are fully addressed through planning and other regulatory frameworks, there is a case for changing the statutory framework to provide for underground access without the complexity and expense of the existing procedure.

Addressing this issue through legislation would remove the possibility that an entire project could be prevented from proceeding due to the objection of just one landowner even if many others consented. It would also remove the need for industry to negotiate with individual landowners for every project, with consequent savings for developers, and for overall investor confidence. This policy will not enable any individual or company to drill underneath private land in an irresponsible manner. All existing regulations

and safety measures will remain in place. The following conditions will still apply to any individual or company who would like to obtain an underground right of access: an abstraction licence (where groundwater is to be utilised) planning permission; permits from the relevant environmental regulator and adherence to current Health and Safety Executive standards.

Policy Objective

To simplify the existing procedure for underground access.

Nothing in the proposed changes will have any effect on other regulatory or legal provisions including the licencing regime (petroleum or water abstraction), planning permission, health and safety regulation and environmental regulation.

Options Considered

The preferred option is to grant underground access to land below 300 metres from the surface to companies extracting geothermal energy in Great Britain. Different payment options for this access have been considered.

A **voluntary payment** from those companies to the **community** located above the underground drilling is **preferred**. This measure includes a reserve power to introduce payment in statute if industry reneges on their voluntary agreement. It removes the costs of identifying individual land owners and negotiating access and removes the potential for delay to and/or cancellation of projects if landowners refuse access, however it may not address individual landowners perceived concerns (e.g. about loss of property rights); this is **Option 3**.

A one-off community payment is significantly less costly to administer than an **individual landowner payment system**, which is **Option 2**.

Under the existing situation a payment could be made to the landowners in return for underground access; however we also considered a **no payment option** for completeness; this is **Option 1**.

In the **Do-Nothing scenario** (carry on with existing underground access processes), the extraction of geothermal energy resources would, in effect, be prevented (this scenario is not analysed further).

Voluntary payments are preferable to payments under statute as they give a greater degree of flexibility in their administration, therefore, being adaptable to meet changing needs and different communities. However, the costs and benefits of the voluntary and compulsory payment options (options 3 and 2) are assumed to be equal within the Impact Assessment.

All payment options include a **notification system**. For the community payment option the notification system is at a community level while in the individual landowner option the notification is per landowner. The administrative costs for the notification have not been added to the overall administrative costs of each payment option, as the administration and type of notification applied for each payment option is intrinsic to the administration of the payment rather than notification per se and therefore it is not appropriate to add any further notification administration costs.

Impact of Policy Options

The primary benefits and costs which drive the Net Present Values (NPVs) reported in this Impact Assessment for Deep Geothermal activity are the direct net benefits/costs to business of supplying heat using a deep geothermal project and the wider benefits to society from carbon emission reductions and air quality improvements.

We believe that administrative costs from the proposed measure will not be additional to DECC. There will be additional administration costs borne by industry under two of the three policy options as set out below. Under the do nothing scenario it is anticipated based upon industry views that no new deep geothermal projects would go ahead in Great Britain over the assessment period under review. All additional projects occur as a result of the access rights issue as set out above being resolved and this leading to the additional deep geothermal activity and consequent carbon savings.

Counterfactual “do nothing” scenario

As discussed under the do nothing scenario it is anticipated that no new deep geothermal projects would go ahead in Great Britain over the assessment period under review. Currently the majority of heat networks in the UK are supplied with heat from a gas boiler according to DECC data on existing heat networks. Future projections of the amount of heat which could be supplied from heat networks produced by Redpoint using their energy system optimisation model (RESOM), on DECC’s behalf show that 1Twh/year of domestic heat demand could have been met by heat networks in 2011 and this rises to 20Twh/year by 2025. These projections can be found in chapter 2 of The Government’s heat strategy *The Future of Heating: Meeting the challenge* (March 2013; https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/190149/16_04-DECC-The_Future_of_Heating_Accessible-10.pdf). As there is a projected increase in heat networks in Great Britain and due to the fact that the six heat networks in the central scenario could also be supplied with heat from a gas boiler if deep geothermal plant development was blocked due to the access rights issue. As the areas in which these six networks would be built are large urban areas with adequate heat demand and so conducive to having a heat network built to meet their heat needs.

An assumption is made in this analysis that under the do nothing option of not resolving the deep geothermal access rights issue large gas boilers would instead be used to provide heat to the networks in the central, low and high Net Present Value NPV scenarios. So the largest impact on society/business of each policy option is the incremental resource cost of heat being supplied using deep geothermal technology rather than gas boilers.

Assessment period

Each deep geothermal project is included in the NPV analysis at the point at which exploration is assumed to start on the basis of the difference in resource costs of future deep geothermal heat production compared to a gas boiler providing this heat. The NPV of all projects beginning construction over the 10 year period 2015–2024 are assessed over their subsequent expected 25 year operating lifetime and 3 year construction period. A 10 year period has been used to assess the additional activity and investment in deep geothermal unlocked by the policy options. Because the policy options do not have a fixed end date, a 10 year period has been used rather than assessing additional activity over a longer time period as the projected number of projects coming forward and the economics of these would become much less certain.

For a new plant commencing construction in the last year of the 10 year period in 2024 this would take 3 years to build and would begin producing heat from 2027 onwards for 25 years to 2051. So the total assessment period is from 2015 to 2051 (37 years) when the last of the deep geothermal projects assumed to begin construction over the 2015–2024 periods operating life would come to an end. The average lifetime of a deep geothermal project would depend on many factors such as the intensiveness of production, hence 25 years is a conservative estimate agreed with industry.

In this analysis it is not assumed that once a deep geothermal comes to the end of its operating lifetime that it would be replaced by another deep geothermal plant. This is because the economics and range of commercially viable renewable technologies which could provide heat to a heat network might be very different to today in 30 years’ time. So when a deep geothermal plant is assumed to cease operation no further costs or benefits are captured for this plant in the NPV.

Methodology

The methodology used to assess the total NPV reported in this impact assessment has involved estimating the benefits/costs to society and business, from the additional deep geothermal projects which proceed on resolution of the access rights issue. This has been done by estimating the incremental resource cost of heat being supplied using a deep geothermal plant as opposed to the most likely counterfactual technology for supplying heat to a heat network, which is currently a large gas boiler.

(a) Resource costs

The resource costs of a deep geothermal project such as the capital and fixed operating costs over its operating lifetime of 25 years and 3 year construction period and the estimated administration costs for handling compensation payments under policy options 2 and 3 are compared with the capital, fixed operating and fuel costs of a gas boiler providing an equivalent amount of heat. As shown below:

$$(\text{Gas boiler capital} + \text{operating} + \text{fuel costs}) - (\text{Deep Geothermal capital} + \text{operating} + \text{compensation administration scheme costs})$$

This then gives the incremental resource cost to society of heat being supplied using deep geothermal technology rather than a gas boiler. The private costs of finance for a deep geothermal plant and counterfactual gas boiler have not been assessed in the NPV because these are treated as transfers.

The deep geothermal projects will be supplying heat primarily to domestic dwellings which are connected to a heat network. The costs of developing a heat network to supply heat from a deep geothermal project have not been assessed in this analysis as these would be comparable to the network costs if a gas boiler were instead used to supply this heat.

(b) Carbon emissions and air quality impacts

The supply of heat using deep geothermal technology will lead to a reduction in overall carbon emissions due to the avoided emissions from gas burnt in a boiler. This reduction in carbon emissions is valued from society's perspective in the NPV using the government's non-traded carbon values. In this analysis deep geothermal technology is assumed to produce no carbon emissions when operating. Although there may be some emissions associated with generating the electricity used to run the plant this is uncertain and would likely produce a negligible amount of carbon emissions according to industry.

The use of a deep geothermal plant rather than gas boilers as discussed above will reduce carbon emissions. DECC uses air quality damage costs to estimate the monetised cost of emissions by fuel type on air quality, the benefit from improved air quality as a result of avoided gas emissions has been estimated using these damage costs and incorporated in the NPV as a benefit.

(c) Administrative costs

Aside from the first policy option, policy options two and three the individual and community based compensation schemes have additional administration costs associated with identifying affected landowners and administering payments. These costs of administration are assumed to be borne by deep geothermal developers and have also been included in the NPV as a cost to business.

(d) Existing subsidy

At the moment new deep geothermal operators would be provided with a subsidy under the DECC renewable heat incentive (RHI) for each kWh of heat produced, to compensate for the estimated higher overall project costs of a deep geothermal plant compared to a counterfactual gas boiler. In the RHI tariff calculation deep geothermal is modelled as requiring subsidy support because capital costs are discounted using commercial rates of return, typically around 12%. This thereby significantly increases the overall costs of a project compared to a gas boiler. As discussed, the private costs of finance incurred on capital spend have not been assessed in the NPV because these are treated as transfers.

The value of the RHI subsidy has not been captured in the overall NPV, business NPV or OITO estimation as this subsidy is treated as a transfer. This analysis is not directly comparable to the RHI tariff setting approach as it does not incorporate private finance costs and a different assumption is made on the number of deep geothermal projects likely to be brought forward based on new industry evidence.

(e) Net Present Value

The total NPV's reported in the summary sheets in addition to the incremental resource cost calculation described above also incorporates the estimated benefit to society from reduced carbon emissions and improved air quality over the assessment period as shown below:

((Gas boiler capital + operating + fuel costs) – (Deep Geothermal capital + operating + compensation administration costs))+ (monetised carbon emissions savings + air quality impacts)

These discounted incremental costs and benefits compared to a gas boiler are then aggregated for each of the deep geothermal projects coming forward over the 2015-2024 period, over their full 28 year construction and operating lifetime to give the aggregate NPV. The present value base year is 2014 for this analysis and a discount rate of 3.5% has been used and where relevant 3% for benefits and costs arising over a longer time horizon. All price series have been converted into 2014 constant prices using the latest Office for Budget Responsibility 2014 RPI inflation rate forecast. The key assumptions and evidence driving the total NPV's reported in this IA are considered in turn below.

Activity levels

An assessment has been made of the potential scale of deep geothermal activity in Great Britain that is likely (a) in the absence of and (b) with the issue of access rights to land being solved. This assessment has been made over a 10 year period from 2015-2024.

Under the do nothing scenario where there is no resolution to the access rights issue. It is assumed that there would be no new deep geothermal power or heat projects proceeding in Great Britain over the assessment period. This assumption is based on the views of the deep geothermal industry that given the high costs which they would face in negotiating to secure access rights with affected landowners and if landowners refused to allow access under the current system they could not proceed. These potential costs and uncertainties make it highly unlikely that any deep geothermal projects would proceed under the do nothing option.

Under the policy options set out in this Impact Assessment, additional deep geothermal activity would occur. The use of deep geothermal technology in Great Britain is limited at present to one scheme in Southampton and use of horizontal drilling at these depths to exploit heat is non-existent. Due to a lack of successful experience this means that the level of future deep geothermal activity in Great Britain is highly uncertain. Future activity will to a great extent depend upon the success of the first few deep geothermal projects which proceed in Great Britain and amount of exploitable heat resources.

Following discussions with deep geothermal developers on the potential for new deep geothermal projects over the period 2015–2024, a conservative projection used in the central NPV is for six new deep geothermal projects beginning construction over this time period. The high and low NPVs in this Impact Assessment show the sensitivity of the NPV to a low deployment scenario where two projects come forward and a high scenario of ten projects. The table below shows the profile for deep geothermal projects commencing construction and supply of heat under the central NPV assumption of six new projects being brought forward.

Year	Number of new Deep Geothermal plants under the do nothing option	Year in which plant construction commences	Year in which plants begin producing heat	Total number of Deep Geothermal plants producing heat
2014	0	0	0	0
2015	0	1	0	0
2016	0	1	0	0
2017	0	0	0	0
2018	0	1	1	1
2019	0	0	1	2
2020	0	1	0	2
2021	0	0	1	3
2022	0	1	0	3
2023	0	0	1	4
2024	0	1	0	4
2025	0	0	1	5
2026	0	0	0	5
2027	0	0	1	6

It is assumed based on industry evidence that it would take 3 years for a deep geothermal project to proceed through the planning, exploration and construction phases to production. The projection of six projects is for heat only projects, deep geothermal projects producing electricity are less likely to proceed over this assessment period, as the economics for power only projects are currently less favourable.

Production levels

The deep geothermal projects assessed for the NPV's reported in this Impact Assessment are assumed to have an operating lifetime of 25 years. In this analysis the operating characteristics for a typical new deep geothermal plant have been used to estimate the NPV. These operating characteristics are based on evidence provided by industry for the setting of the DECC Renewable Heat Incentive tariff for deep geothermal projects.

New deep geothermal plants are assumed to have a 6000 Kilo Watt capacity size and operate at an average load factor of 55%. This translates into a typical deep geothermal plant producing 28,908 Mega Watt hours of heat each year, based on the assumption that the plant operates for 24 hours a day all year round which would equate to 8760 hours a year, at a load factor of 55% (the percentage of overall plant heat production capacity used on average over a year). The assumption around a load factor of 55% has been agreed with industry, this reflects the seasonal nature of heat demand with higher demand in the winter and lower demand in the summer months. Deep Geothermal developers believe that there will be limited time required over the course of the year to carry out plant servicing and this has been factored into the load factor estimate. However, the load factor of future plants may be higher than 55% or indeed lower and 55% is a conservative assumption.

Heat produced by a typical deep geothermal plant over a year = 6,000 kW capacity * 8,760 hours in a year * 55% load factor/1000 = 28,908 MWh.

The counterfactual gas boiler is assumed to have a similar load profile and capacity size. In the analysis it is also assumed that it takes 3 years for a deep geothermal plant to progress from the planning, exploration and construction phases to heat production. For a gas boiler it is assumed based upon evidence on industry installation times that a gas boiler can be installed and operating in 2–3 months, as no exploration/drilling would be required making the installation phase much less time intensive.

The actual production levels of future deep geothermal plants is highly uncertain given adequate customers for the heat, the load factors at which these plants might operate might be much higher. The level of production would also depend upon the amount of exploitable deep geothermal resource at each site, which is again highly uncertain.

Resource costs

A key component of the NPV for deep geothermal activity is the estimation of the difference in resource costs between using deep geothermal technology to provide heat and the alternative of a gas boiler.

The resource costs for a deep geothermal project assessed in the NPV are the capital and operating costs. The data on capital and operating costs are taken from evidence provided by industry on the likely costs of a typical new deep geothermal plant. Operating costs for a deep geothermal plant do not include any estimate of the electricity costs associated with running the plant. There was one estimate for likely electricity running costs from a single industry source. However, this has not been validated, costs would probably vary substantially between different projects and electricity operating costs have not been raised by a (number of industry stakeholders) as being a substantial cost. For this reason estimates of future electricity costs of running a deep geothermal plant have not been incorporated in this analysis. There are assumed to be no other fuel costs associated with running a deep geothermal plant.

The capital and operating cost data for a typical deep geothermal plant used in this analysis was also used to set the Renewable Heat Incentive tariff for deep geothermal technology, these costs have also been discussed and validated by industry through recent contact. In the analysis the full capital costs of a deep geothermal plant are assumed to be borne in the first year of the three year construction period. This is because the bulk of a project capital costs such as the exploration and equipment costs for developers would be incurred around the first year.

In this analysis the capital costs of deep geothermal projects are reduced by 10%, after the first two projects this reduction is due to the learning benefits from these early projects for subsequent project developers and this assumption has been agreed with industry. The analysis also does not assume that there are any decommissioning costs when a deep geothermal plant comes to the end of its operating lifetime, because industry has advised that there would be very small but uncertain costs associated with decommissioning the plant.

The resource costs for a gas boiler which are assessed in the NPV include capital, operating and input fuel costs. The capital and operating costs are taken from data collected by Ricardo AEA on behalf of DECC through engagement with industry and suppliers. The capital costs of a gas boiler are assumed to be borne in the first 2-3 months of the first year in which the boiler begins the supply of heat. In the analysis as the first deep geothermal plant begins producing heat in 2018, the counterfactual gas boiler would also produce heat from the same first year of heat production as this first project. Subsequent counterfactual gas boilers would also start producing heat from the same year as the counterfactual deep geothermal plant.

A major component of the running cost of a gas boiler is the input fuel cost for the gas consumed. The input fuel expenditure which would have been incurred by gas boilers to provide heat is included in the NPV calculation of the difference in resource costs between a deep geothermal plant and gas boiler.

The DECC Interdepartmental Analysts Group (IAG) central long run variable cost of gas supply LRVC series (which can be found in table 10 of the DECC appraisal toolkit <https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal>) is used to value what the cost of this gas consumption would have been from society's perspective in each year. The LRVC of gas is used to value changes in energy consumption and represents the cost to society of supplying an additional marginal unit of gas to the local distribution and transmission network for final consumption. In the business NPV and OITO estimation retail prices for gas are used.

The table below shows the capital and operating costs (excluding input fuel costs) of a typical deep geothermal plant and gas boiler used in this analysis in 2014 prices:

Capital and operating costs	Deep Geothermal	Gas Boiler
Capital costs £ per kW	£2,510	£71
Operating costs £ per kW per year	£25	£2

The table below shows the total overall estimated capital and annual operating costs (excluding input fuel costs) for a 6,000 kW capacity deep geothermal plant and gas boiler in 2014 prices:

Capital and annual operating cost	Deep Geothermal	Gas Boiler
Total capital cost	£15,059,115	£424,949
Total operating cost per year	£152,176	£13,075

As the table shows the capital cost of a typical deep geothermal project is estimated to be around £15 million, whilst the cost for an equivalent gas boiler is around £400,000.

Carbon impacts

An increase in the roll out of deep geothermal projects will cause a reduction in UK carbon emissions. This is due to the fact that heat produced using deep geothermal technology will displace heat which would have been produced using a gas boiler and have associated carbon emissions.

An estimate has been made of the tonnes of carbon which are no longer emitted due to deep geothermal heat production. This has been estimated by calculating the amount of gas which would have been used by a gas boiler (in this analysis assumed to have a 90% efficiency) to produce an equivalent amount of heat and applying DECC's 2013 CO₂ natural gas emissions factor (0.1837 kg Co₂ per kWh) to estimate how much carbon would have been emitted. On average each Deep Geothermal plants annual output of heat reduces carbon emissions by 5,900 tonnes per year.

Carbon saving in tonnes from a typical deep geothermal plant each year compared to emissions from a gas boiler to produce an equivalent amount of heat:

$$= 28,908 \text{ MWh heat} / 90\% \text{ counterfactual gas boiler efficiency (this gives the avoided gas burn)} * 1000 * 0.1837 / 1000 = 5,900 \text{ tonnes of carbon}$$

These carbon emissions would occur in the non-traded sector as these emissions would not be capped or traded under the EU emissions trading scheme. The estimated CO₂ emissions avoided from not using a gas boiler to produce heat, have then been monetised using the government's central non-traded price of carbon for each relevant year over the 2015-51 period converted to 2014 prices. The non-traded carbon price (which can be found in Table 3 of the toolkit

<https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal>) shows the marginal costs of abatement for society as a result of an additional tonne of carbon emission in the non-traded sector in each future year.

In valuing emissions, the UK Government adopts a target-consistent approach, based on estimates of the abatement costs that will need to be incurred in order to meet specific emissions reduction targets. The monetised carbon impact of additional deep geothermal activity has then been incorporated into the NPV as a benefit due to the avoided costs of abatement associated with the carbon emissions from a gas boiler which are avoided.

Air quality

The use of deep geothermal plants rather than gas boilers will reduce carbon emissions due to the avoided emissions from gas burnt in a boiler. This will lead to an improvement in air quality, DECC uses air quality damage costs to estimate the monetised cost of emissions by fuel type on air quality.

"Damage costs" have been calculated using a range of representative emissions in order to estimate an average marginal effect for each additional tonne of gas introduced into the atmosphere. These primarily value health impacts, though non-health impacts are also included. The DECC air quality damage cost for gas (pence/kWh) series (which can be found in Table 15 of the toolkit

<https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal>) in a domestic inner conurbation and estimated overall reduction in gas consumption due to the six deep geothermal plants supplying heat in the central scenario have been combined to estimate the benefit to society of improved air quality and incorporated as benefit in the NPV.

Administration costs of policy options

Under the first policy option, no payment is provided to affected landowners in return for underground access rights. The second and third policy options, which would provide for compensation payments by deep geothermal developers to the community or individual landowner owning land above the underground drilling, would have administration costs associated with identifying relevant landowners, setting up the payment and ensuring this is recorded. Under the do nothing scenario no deep geothermal plants are assumed to proceed so there are no administration costs.

Under each of these two policy options: a community or individual compensation scheme there would also be a nominal payment to the affected parties in return for access. This payment is not included in the NPV as this would be a transfer between deep geothermal developers and recipients.

The estimated average cost to business per site to administer the compensation due under the proposed option varies from zero (Option 1) to £25,000 (Option 3) to £135,000 (Option 2). These cost estimates have been informed by discussions with industry and are consistent with the costs assumed in the oil and gas access rights Impact Assessment. Although, assuming that 3,000 landowners would be affected rather than 1000. This assumption of 3000 landowners is based on industry evidence on the average number of landowners near potential deep geothermal projects who would have their land accessed for underground drilling.

For Option 3 the cost is an estimate of that involved in holding a few workshops to discuss project ideas and implementing the project(s) in the community. It is not thought that this cost would increase with the

number of landowners affected rising from 1000 to 3000. The greater cost for Option 2 reflects the need to make payments to numerous individuals. The estimated cost of around £135,000 assumes payments to 3,000 landowners. The total comprises £13,500 for Land Registry searches (at £4.50 per property), £45,000 for administrative costs to prepare letters, make payments to the landowners, log the process and answer telephone queries and £75,000 to employ 3 GIS experts for 6 months to deal with the Land Registry, identify landowners, convert data into appropriate formats, etc. These estimates have been informed by discussions with existing shale gas licensees and deep geothermal developers but are inevitably speculative at this stage and may be lower per individual for deep geothermal projects due to greater scope for economies of scale.

Administrative Costs for Government

The administrative costs for HMG depend entirely on the extent of new activity, in particular the number of new deep geothermal projects coming forward over the assessment period. Under the central assumption of deployment, there would probably be 6 new deep geothermal projects. Given this scale of deployment there would be a relatively insignificant incremental administrative cost associated with the granting of planning permission and regulating the exploration for and extraction of deep geothermal heat in Great Britain.

Environmental Impacts

All deep geothermal projects extracting heat, require planning permission and are subject to operational regulation by the relevant environmental agency (i.e. the Environment Agency, the Scottish Environment Protection Agency or Natural Resources Wales, as the case may be). The conduct of permitted operations will have to meet the environmental standards specified by the environment agency.

Summary

The total Net Present Values under the central and low/high scenarios of new deep geothermal plant deployment over 2015–2024 are shown in the tables below for each of the three policy options.

The table below show a breakdown of the total incremental difference in costs (operating, capital, fuel and carbon) between the six deep geothermal plants in the central scenario compared to gas boilers in providing heat. The difference in resource costs shows the difference in capital and operating costs. For instance due to the higher capital and operating costs of a deep geothermal plant compared to a gas boiler, it would cost an additional £80 million to provide heat using deep geothermal technology.

The difference in fuel costs shows the difference in the cost of fuel required to run a gas boiler and deep geothermal plant (in the analysis it is assumed that a deep geothermal plant does not incur any fuel costs associated with running the plant) using deep geothermal saves around £68 million in fuel costs.

The carbon impact shows the benefit to society of deep geothermal plants proving heat rather than gas boilers. There is a benefit to society of around £49m over the assessment period due to reduced carbon emissions taking place and hence no costs to society from carbon abatement. Additionally there are benefits from air quality improvements. The administration costs show the costs for deep geothermal developers of having to pay for the administration of compensation either to individuals or communities.

The table below shows the total discounted NPV in 2014 prices for each of the three access rights policy options for the central NPV, which assumes six projects being brought forward:

£m 2014 prices	Option 1	Option 2	Option 3
Difference in resource cost	-80	-80	-80
Difference in fuel costs	68	68	68
Monetised carbon impact	49	49	49
Air quality impact	3.7	3.7	3.7
Total administration cost	0	-0.68	-0.13
Total NPV	£41.1m	£40.5m	£41.0m

The total assessment period is from 2015-2051, 2051 is the year in which the last of the 6 deep geothermal plants in the central scenarios operating life comes to an end.

NPV Sensitivity high and low deployment scenarios

The table below shows the total NPV for each of the three access rights policy options for the low NPV scenario, which assumes two projects being brought forward over the assessment period:

£m 2014 prices	Option 1	Option 2	Option 3
Difference in resource cost	-32	-32	-32
Difference in fuel costs	26	26	26
Monetised carbon impact	16	16	16
Air quality impact	1.3	1.3	1.3
Total administration cost	0	-0.26	-0.05
Total NPV	£10.8m	£10.5m	£10.8m

In the low NPV scenario two projects commence construction one in 2015 and the other in 2016. The low NPV is assessed over a 29 year assessment period covering the years 2015–2043. With the first project commencing construction in 2015 and its operating lifetime ending in 2042 and the second plant starting construction in 2016 and retiring in 2043.

The table below shows the total NPV for each of the three access rights policy options for the high NPV scenario, which assumes ten projects being brought forward over the assessment period:

£m 2014 prices	Option 1	Option 2	Option 3
Difference in resource cost	-130	-130	-130
Difference in fuel costs	112	112	112
Monetised carbon impact	83	83	83
Air quality impact	6.1	6.1	6.1
Total administration cost	0	-1.12	-0.21
Total NPV	£70.9m	£69.7m	£70.7m

In the high NPV scenario 10 projects commence construction over the assessment period and subsequently begin producing heat. This equates to one new deep geothermal project beginning construction each year over the 2015-2024 period. With the last plant commencing construction and the supply of heat in the same years as the last plant in the central scenario, so the total assessment period is 37 years covering the period 2015-2051.

These NPVs are the accumulation of the total discounted incremental resource costs/benefits, administration costs, air quality and monetised carbon impacts of deep geothermal projects rather than gas boilers being used to supply heat over their 25 year operating lifetime and 3 year construction phase. The difference in administration costs between the options has a small impact on the NPV. In the central scenario based on the assumptions described above, the NPV of selecting the favoured policy option rather than the do nothing option is £41million (in 2014 prices).

Rationale and evidence that justify the level of analysis used in the IA

There is a great deal of uncertainty on the number of deep geothermal plants which may begin exploration and operation over the 2015–2024 period. The central estimate used in this analysis is based upon a conservative view of the number of projects which are likely to be brought forward on resolution of the land access rights issue that has been agreed with industry. Sensitivity has been carried out on the main uncertain assumption around how many projects are likely to proceed to production of heat over the assessment period.

Data on likely numbers of new projects and resource costs for future deep geothermal plants has been taken from data provided by industry and compared against other sources where possible. DECC projections converted into 2014 prices using the latest Office for Budget Responsibility 2014 RPI inflation

rate forecast, have been used for things such as carbon valuation, air quality and fossil fuel price projections in the analysis.

Changes to assumptions on future production levels, capital and operating costs could also have been considered but the range of net benefits presented is thought to be wide enough to bracket the likely true impact of the measure. Future production levels and projected deep geothermal plant operating lifetimes are also based on conservative estimates.

Business Net Present Value

The business NPV detailed in the Impact Assessment is estimated as the incremental cost/benefit to business of using deep geothermal technology to supply heat rather than a gas boiler. At the moment businesses (heat network owners/developers) could potentially use a gas boiler to supply heat to a heat network rather than a deep geothermal plant. It is thought that if deep geothermal plants are not used to supply heat to heat networks, then given the increasing rollout of networks, under the do nothing option of not resolving the deep geothermal access rights issue gas boilers would instead be used.

The business NPV is estimated for the six deep geothermal projects which are projected to proceed over the 2015-2024 period consistent with the central NPV scenario after the access rights issue is resolved for their 25 year operating lifetime and 3 year construction period (the total assessment period covers 2015-2051). The impact on business is the incremental resource cost/benefit of a deep geothermal plant producing this heat rather than a counterfactual gas boiler. The carbon and air quality impacts of the policy options incorporated in the NPV have not been incorporated in the business NPV as these have indirect impacts on business.

The business NPV reported in the Impact Assessment is estimated as follows:

$$(\text{Gas boiler capital, fixed operating and fuel costs}) - (\text{Deep Geothermal capital, fixed operating and compensation scheme administration costs})$$

The overall incremental costs/benefits to business from using deep geothermal technology for each plant over its operating lifetime and construction have then been discounted to give the total net cost/benefit to business of using deep geothermal technology rather than a gas boiler to supply heat. The capital and operating costs of a deep geothermal plant and gas boiler, as well as the estimated administration costs of the compensation schemes used to estimate the business NPV are the same as those used in the total NPV calculations.

The gas boiler counterfactual input fuel costs for gas used to produce heat are estimated by applying the DECC central industrial retail price of gas p/kWh (which can be found in table 5 of the toolkit <https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal>) price series to the counterfactual gas boilers estimated gas consumption. The industrial retail price for gas is used as this rather than the wholesale price is likely to approximate the cost that businesses would pay for the gas which they would use to run a heat networks gas boiler. The LRVC of gas is not used as the business NPV represents the impact on business rather than society. In the central NPV scenario the difference in resource costs between the six deep geothermal plants and gas boilers was £80 million and the saving from avoided gas input fuel costs around £68 million. However, in estimating the counterfactual gas boiler input fuel costs for the business NPV the LRVC of gas, is not used but rather the retail industrial gas price which on average is around 19% higher than the LRVC of gas. This results in a small positive business NPV as avoided gas boiler input fuel costs for business are higher.

The table below shows the overall business NPV in 2014 prices for each of the three policy options based on the central deployment of six projects:

Total Business NPV	Option 1 no compensation	Option 2 individual compensation	Option 3 community compensation
£m	1.54	0.86	1.42

Under policy option 3 the community based compensation scheme this generates a small positive business NPV of £1.42 million.

One-in, two-out

Apart from the benefits to society from reduced carbon emissions and air quality impacts, all of the monetary costs and benefits of the policy options fall upon business; these include the costs of activity, administration costs and benefits from selling heat. Any environmental effects have an indirect impact upon business.

The equivalent annual net cost to business EANCB reported in this Impact Assessment has been derived based on the estimated profit generated by business from two deep geothermal projects. Rather than claiming the benefit of unlocking the entire deep geothermal industry we have assessed the benefit based on a conservative estimate of two projects proceeding. These projects we know based on industry advice are highly likely to proceed rapidly to commencing exploration/construction in 2015 and 2016 but are currently being held up due to the access rights issue. The EANCB is assessed over a 29 year assessment period covering the years 2015–2043. With the first project commencing construction in 2015 and its operating lifetime ending in 2042 and the second plant commencing construction in 2016 and retiring in 2043.

For these projects a methodology explained below has been used to estimate the additional net profits to the deep geothermal industry from their producing and selling on heat to customers and this forms the basis of the EANCB reported in this Impact Assessment. The EANCB has been estimated for policy Option 3, the community based compensation scheme the preferred policy option.

Firstly the overall lifetime costs of supplying heat using a deep geothermal plant have been estimated these include the administration costs associated with administering community compensation payments, capital and fixed operating costs (which are the same as those used in the total and business NPV estimation) for the two deep geothermal plants.

To assess the profits which these deep geothermal developers would make on heat sold to consumers, an assumption has been made on the price at which deep geothermal developers are likely to sell heat to customers. It is uncertain at what price deep geothermal developers would sell their heat. Industry has also been reluctant to share data on their pricing strategies due to commercial sensitivity.

For the purpose of this analysis the price which heat is sold for is assumed to be set with reference to the domestic retail price of gas p/kWh, as this is the price which domestic customers using a gas boiler to heat their home would have to pay for their gas consumption in the absence of being supplied with heat from a network (ignoring for simplicity the cost of a boiler). So it is assumed as a simplifying assumption that the price of heat supplied through a heat network from a deep geothermal plant or a gas boiler would be set in line with the retail price for domestic gas.

The gas price used to estimate the price at which deep geothermal developers will sell their heat to customers is the DECC central retail domestic gas price series (which can be found in Table 5 of the toolkit <https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal>) in 2014 prices. This pricing methodology would provide a benefit to consumers compared to gas consumption as no adjustment has been made for the lower efficiency of a gas boiler.

So for instance based on the annual production of a deep geothermal plant of 28,908 MWh of heat, consumers would pay the equivalent price for this heat of 28,908 MWh of gas priced at the retail domestic price under the above pricing strategy. Whereas if consumers had been supplied with heat from a large gas boiler (90% efficient), it would mean consumers paying the equivalent of 11% more. This lower cost for heat would ensure that deep geothermal heat is competitively priced compared to heat supplied from a gas boiler.

For the EANCB purpose the direct cost of supplying heat in each year for the two projects including the capital, operating and administration costs over their 28 year construction and operating life is taken

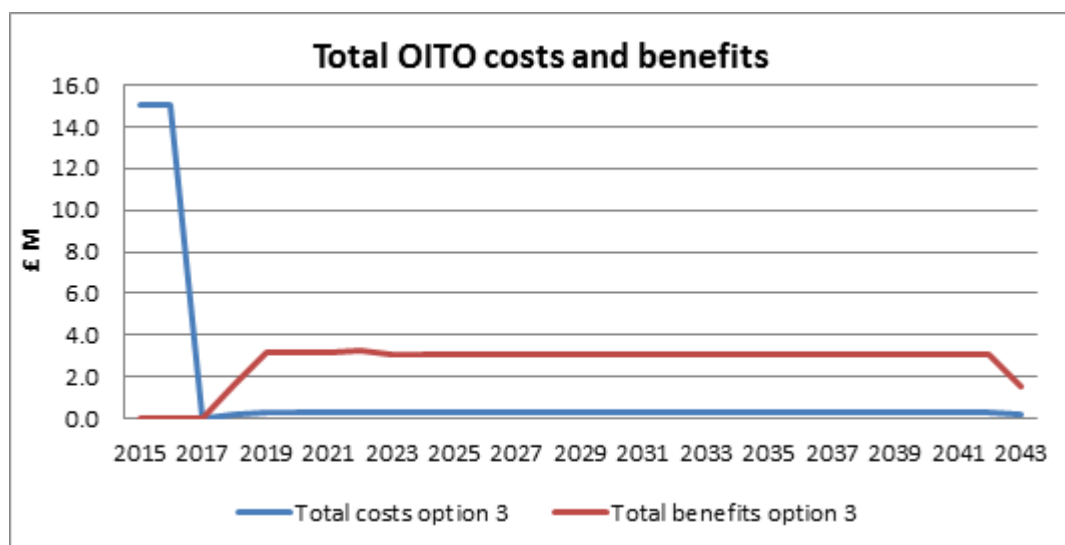
away from the estimated revenue achieved from selling heat, this then gives the total profitability of the deep geothermal plants over their operating lifetime with the formula used shown below.

Net profits to business from the two deep geothermal plants:

$$= (\text{Total deep geothermal heat production} * \text{Domestic gas retail price}) - (\text{Total Deep Geothermal capital} + \text{operating} + \text{administration costs})$$

The total annual costs and profits for each plant over the 3 year construction and 25 year operating lifetime have then been used to estimate the EANCB for the preferred policy option of a community compensation scheme as reported in the impact assessment using the EANCB calculator.

The graph below shows the direct costs and benefits to business from the two additional deep geothermal plants used to estimate the EANCB over each plant's 28 year construction and operating lifetime (3 and 25 years). This is based on the community based compensation scheme option 3.



In the first two years 2015 and 2016 the capital costs of the deep geothermal plants are incurred around £15m for each plant. In subsequent years costs are around £300,000; these are the estimated fixed costs of operating the plants. The deep geothermal plants make benefits of around £3m each year based on the revenue from heat sales estimated using the methodology for calculating profits described above. In 2017 costs and benefits are zero as capital costs have been incurred for the first deep geothermal plant but production of heat has not yet begun. Most of the lifetime costs of the deep geothermal plants are borne in the first few years and hence less heavily discounted, whilst profits occur over a 25 year period and are more heavily discounted in later years.

The EANCB has been derived using the EANCB calculator with input annual net benefits and costs calculated as described above based on the preferred policy option of a community based compensation scheme. **Based on the EANCB calculations this represents a total annual OUT of -£0.52 million for this policy option.**

Wider impacts

Each option is expected to have no negative impact on the justice system. The proposals simplify the current process for underground access, under which court cases can be brought due to (a) a landowner refusing access and the operator in the case of oil and gas referring the case via the Secretary of State to the court (via Mines (Working Facilities and Support) Act 1966); or (b) in the case of trespass, if the operator accesses land without appropriate permission from the land owner. The first of these two possible impacts on the justice system will be removed in respect of oil and gas in underground land below 300 metres, and the second of these will be removed in respect of oil, gas and geothermal energy, therefore the policy will reduce the potential burden on the justice system.

Consequences for security of supply and energy prices have not been quantified as they are judged to be second order given the small amount of gas consumption avoided. Any benefits from reduced

renewable supply chain costs as a result of greater deep geothermal plant deployment have not been estimated due to uncertainty on the likely impact. There is assumed to be no impact upon SMEs or significant impact upon heat market competitiveness.

Summary and preferred option with description of implementation plan

The government has consulted on options including its preferred option (Option 3) – see <https://econsultation.decc.gov.uk/decc-policy/consultation-on-underground-drilling-access>.