GREBE

Generating Renewable Energy Business Enterprise

Northern Periphery and Arctic Programme 2014-2020

Advice Notes on Geothermal Economics for the NPA Region

www.grebeproject.eu

The GREBE Project

What is GREBE?

GREBE (Generating Renewable Energy Business Enterprise) is a €1.77m, 3-year (2015-2018) transnational project to support the renewable energy sector. It is co-funded by the EU's Northern Periphery & Arctic (NPA) Programme. It focuses on the challenges of peripheral and arctic regions as places for doing business, and helps develop renewable energy business opportunities in areas with extreme conditions.

The project partnership includes the eight partners from six countries, Western Development Commission (Ireland), Action Renewables (Northern Ireland), Fermanagh & Omagh District Council (Northern Ireland), Environmental Research Institute (Scotland), LUKE (Finland), Karelia University of Applied Sciences (Finland), Narvik Science Park (Norway) and Innovation Iceland (Iceland).

Why is GREBE happening?

Renewable Energy entrepreneurs working in the NPA area face challenges including a lack of critical mass, dispersed settlements, poor accessibility, vulnerability to climate change effects and limited networking opportunities.

GREBE will equip SMEs and start-ups with the skills and confidence to overcome these challenges and use place based natural assets for RE to best sustainable effect. The renewable energy sector contributes to sustainable regional and rural development and has potential for growth.

What does GREBE do?

GREBE supports renewable energy start-ups and SMEs:

- To grow their business, to provide local jobs, and meet energy demands of local communities.
- By supporting diversification of the technological capacity of SMEs and start-ups so that they can exploit the natural conditions of their locations.
- By providing RE tailored expert guidance and mentoring to give SMEs and start-ups the knowledge and expertise to grow and expand their businesses.
- By providing a platform for transnational sharing of knowledge to demonstrate the full potential of the RE sector by showcasing innovations on RE technology and strengthening accessibility to expertise and business support available locally and in other NPA regions.
- To connect with other renewable energy businesses to develop new opportunities locally, regionally and transnationally through the Virtual Energy Ideas Hub.

- By conducting research on the processes operating in the sector to improve understanding of the sector's needs and make the case for public policy to support the sector.

For more information, visit our website:

http://grebeproject.eu/

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The Advice Note aim to provide introductory material for entrepreneurs, startups and SME's, considering to enter into the renewable energy sphere and based in the NPA regions partners to GREBE. The scope of the Advice Note covers regional, trade and industry, renewable energy (RE), technology information from Ireland, Northern Ireland, Scotland, Iceland and Finland. Different partner regions have different level of deployment of the various RE technologies covered by the Advice Notes. Thus, the level of information will vary depending on the level of deployment for each technology. For example, deep geothermal is deployed on a large scale in Iceland and not as much in Scotland, Finland, Ireland and Northern Ireland.

The focus of the Advice notes is to provide regional partner information on some of the main economic characteristics, sited as imperative, when making an informed choice, regarding which RE technology may be the optimal choice for the business:

- Costs and economics associated with the relevant technology
- Support schemes available, relevant to the technology
- Government allowance/exemptions, relevant to the technology
- Funding available for capital costs of the relevant technology
- List of the relevant to the technology suppliers/developers, with focus on local/regional suppliers/developers and the products and services they offer.

The technologies that are covered in the Advice Note are the following:

- *Biomass CHP*
- *Wind*
- Solar PV
- *Small – scale Hydro (SHP)*
- *Anaerobic Digestions (AD)*
- ***Geothermal***
- *Air source heat pump*
- *Ground source heat pump*
- *Energy storage*
    - *Electric (batteries)*
    - *Thermal (heat storage)*
    - *Chemical (hydrogen – fuel cell and electrolysis).*

The selection of the right RE technology will also be determined by the balance of energy demand of the business, the prospect to exploit local natural resources and the existing supply network. Assessing the energy mix assists in determining which RE technology is apt for your business. These matters will be discussed in depth in the Renewable Energy Resource Assessment Toolkit.

Geothermal Economics Across the NPA

It is understood that the ultimate source of geothermal energy is radioactive decay occurring deep within the earth. In most regions, this heat reaches the surface in a very diffuse state. Nevertheless, due to a range of geological processes, some areas, including substantial portions of the NPA region, are underlain by comparatively shallow geothermal resources. The map (Figure 1.) below of global geothermal use shows that geothermal energy is exploited across the whole NPA region, mainly through direct use, with the help of ground source heat pumps (GSHP).

However, Iceland is taking geothermal power and technology to an advanced level by exploiting the resource for power generation. Other countries in the NPA region are exploring options of exploiting the geothermal resources by the use of deep geothermal technology but are still far behind compare to Iceland.

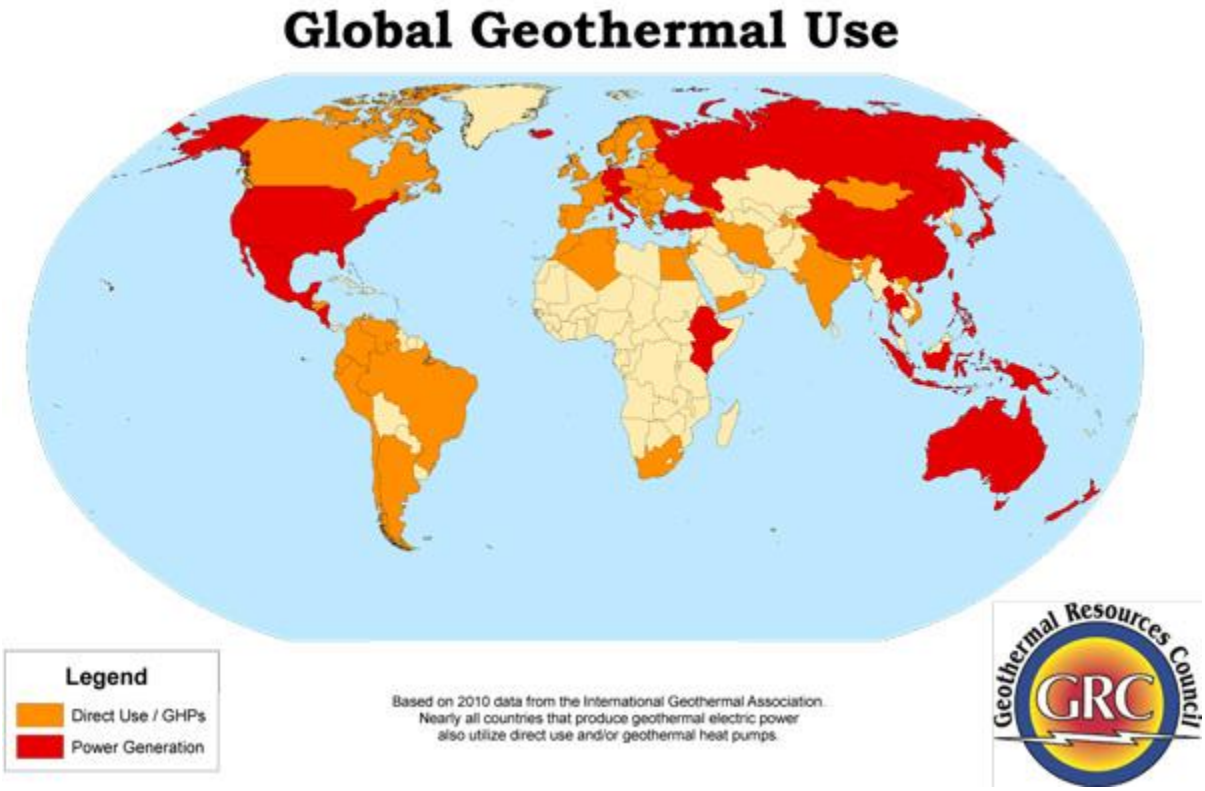

Figure 1. Global Geothermal Use Map. [1]

Geothermal resources can be divided in three different categories depending on their utilization:

- Low-temperature utilization if the temperature of the source is below 150°C
- Intermediate temperature resources 150-200°C
- High-temperature utilization if the temperature of the source is higher than 200°C

The value of the resource depends on

- Temperature
- Available flow rate
- Chemistry of the geothermal fluid
- Distance from potential market

[1] https://geothermal.org/what.html

Geothermal energy can be used directly for providing heat, utilized by geothermal power plants as a district heating source. It is an exceptionally site specific form of energy and is generally divided in 3 sub-categories of application, heat pumps are already discussed in a separate piece of Advice Notes and the other two are as follows:

- Direct heat uses - encompasses using the heat in the water directly (without a heat pump or power plant) for such things as heating of buildings, industrial processes, greenhouses, aquaculture, space heating/cooling and resorts. Direct use developments usually use resource temperatures between 38°C to 149°C. Direct use of geothermal energy in commercial operations can be much cheaper, if the right resources are available, than using traditional fuels; savings can be as much as 80%.
- Electricity generation - geothermal plants require high temperature (150°C to 380°C) hydrothermal resources that may come from either dry steam wells or hot water wells. The resource is exploited by drilling wells into the Earth and piping the steam or hot water to the surface. Geothermal wells are typically one to two miles deep.
- Enhanced Geothermal Systems (EGS) - reservoirs drilled to upsurge the economics of resources with inadequate water and/or permeability and can offer good potential for increasing the use of geothermal energy. The EGS model is designed to extract heat by crafting a subsurface fracture system, add through injection wells and create an enhanced geothermal system by improving the natural permeability of rock.

The main parameters governing geothermal power economics include[2]:

- Capital costs (CAPEX) – the initial construction costs of a geothermal facility can be very expensive representing more than two thirds of total costs. There are many factors that influence the cost of a geothermal project such as size of the plant, technology, knowledge and temperature of the resource, chemistry of the geothermal water, resource depth and permeability, tax incentives, markets and financing options and cost. Drilling costs may differ as well as geothermal projects are site-specific, thus the costs to connect to the electric grid will be different for each project.
- Operational cost (OPEX) – The operating costs of geothermal are very low and insusceptible to fluctuations in fossil fuel costs.

[2] Renewable Energy: Technology, and Environment Economics, 2007.

- Electricity/Heat production - cost of producing electricity over time is lower because the price and availability of the fuel is stable and predictable. The fuel does not have to be imported or transported to the power plant or to the business (direct use), it's directly underneath and it's free. Capacity factors for geothermal energy power production are often quoted at rates of 85%.
- Geothermal lifetime - long lifespan up to 30 years.

The key benefit of using geothermal energy for direct use projects in the low- to intermediate-temperature range is that these resources are prevalent and exist in at least 80 countries at economic drilling depths. Furthermore, there are no conversion efficiency losses, and projects can use conventional water-well drilling and off-the-shelf heating and cooling equipment. Most projects can be completed in less than a year. Projects can be on a small scale (single greenhouse, aquaculture pond. etc.) but they can also be a largescale commercial operation (district heating/cooling, food and lumber drying. etc.).The advantages of geothermal energy over conventional energy stem from the fact are that heat and power from the earth is infinite, 24 hours a day throughout the year. It is a proven and mature technology, independent of the season, climatic conditions and day time.

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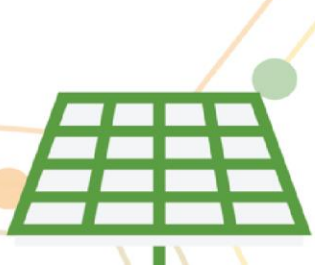
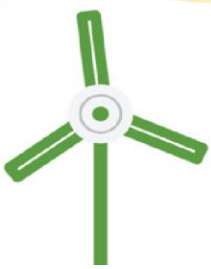
Scotland





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Costs and economics

Deep geothermal direct heat systems are commercially feasible where an adequate flow of hot water can be established at manageable depths, and at a sensible distance from the customers. In the UK geothermal is at an early stage of project development and geothermal projects are heat only projects where the heat would be delivered to district heating networks. Compared to other RET, geothermal in non-volcanic regions is one of the least commercially proven. At present geothermal is a high-cost technology with substantial effort necessary to discover suitable geothermal sites.

To manage project risk schemes are developed using a phased method to evaluate capital costs, locate sites and customers. Comprehensive costs and risks analysis is not 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). Estimate costs for heat only geothermal energy is Europe is between £0.93M to £2.00M/MW compared to £3.0M/MW for offshore wind.

- LCOE – Average LCOE is around 166 £/MWh, for district heating it can be– £0.04 / kWhth to £0.11 / kWhth. However, as a result of early-stage drilling costs, CAPEX for geothermal are relatively high compared to the marginal cost of connecting to the gas grid for example. The table below is adapted from a study into the Potential for Deep Geothermal Energy in Scotland by the Scottish Government, showing average LCOE and predicted LCOE for electricity generation and heat production from geothermal resources.

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

Table 1 3

- CAPEX - For all forms of geothermal the most significant cost relates to the generation equipment and borehole drilling. Combining the pre-development, construction and infrastructure costs together total £7.13m/MW. The risk of failure for the first few boreholes in a given reservoir is around 40%, but this drops to less than 10% after the first few holes are drilled and knowledge of the reservoir grows. With increasing capacity and depth costs will increase too, but increasing the depth of the geothermal well increases the efficiency for this type of project.
- OPEX - Operating costs for geothermal plants are primarily driven by the labour required to operate and maintain production and generation equipment. Average operating cost is around, £187k/MW and is expected to be mainly driven by project specific project conditions, availability of equipment, skilled labour.

Support Schemes

Renewable Heat Incentive[3] - Tariffs can be found below for installations

Description	Total Installed Capacity (kW)	Eligible Tariff (pence per kWh)
Deep Geothermal	All capacities	5.22

Government Allowances and/or Exemptions

N/A

Funding available for Capital Costs

N/A

[3] https://www.gov.uk/domestic-renewable-heat-incentive

Technology suppliers, products and services they offer

Supplier	Services	Contact Information
Town Rock Energy	They provide feasibility studies that recommend on the geological and economic viability of producing energy from both shallow and deep geothermal resources. Process core and field samples for geothermal properties, including thermal conductivity, porosity and permeability. Provide a consultancy service on all geothermal opportunities on any scale.	E: info@townrockenergy.com P: 07841 910719

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Ireland

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Geothermal Economics Ireland

Costs and economics

Cost and economics - The initial capital costs of installing a geothermal heat pump system is usually higher than other conventional central heating systems. A large proportion of the outlay will be for the purchase and installation of the ground collector. The system is among the most energy efficient and cost effective heating and cooling systems available.

Typically, 3-4 units of heat are generated for every unit of electricity used by the heat pump to deliver it, and the payback is typically about 8-10 years. The life expectancy of the system is around 20 years. Once installed a heat pump requires very little maintenance and anyone installing a heat pump should speak with their installer regarding a maintenance agreement. Heat pumps operate optimally when a system design approach is taken. It is important that the heat collector and heat distribution systems are correctly sized/installed.

Support Schemes

N/A

Government Allowances and/or Exemptions

ACCELERATED CAPITAL ALLOWANCE SCHEME (ACA)

The ACA is not a grant, but rather a tax incentive for companies paying corporation tax and aims to encourage investment in energy efficient equipment.

The ACA offers an attractive incentive whereby it allows companies to write off 100% of the purchase value of qualifying energy efficient equipment against their profit in the year of purchase. Eligible equipment can be chosen from the Triple E register (See solar databases – Triple E) and includes solar heating and electricity technologies.

Funding available for Capital Costs

N/A

Technology suppliers, products and services they offer

Developer	Services	Contact Information
Pure Energy Technologies	Multiple boreholes are commonly used in large installations where very high levels of heat extraction are required. Available in a wide range of sizes and configurations, Dimplex ground source heat pumps provide a sustainable heating solution for virtually any scenario. As well as being perfectly suitable for use with either radiators or underfloor heating systems, Dimplex ground source heat pumps can also provide domestic hot water. Single phase models are available in outputs from 5-16kW making them ideal for both domestic and light non domestic applications alike, while the option of either stand alone or fully integrated formats provides maximum flexibility to meet the needs of virtually any scenario.	Kilmallock Road, Bruff, Co. Limerick, Ireland **E:** sales@pet.ie

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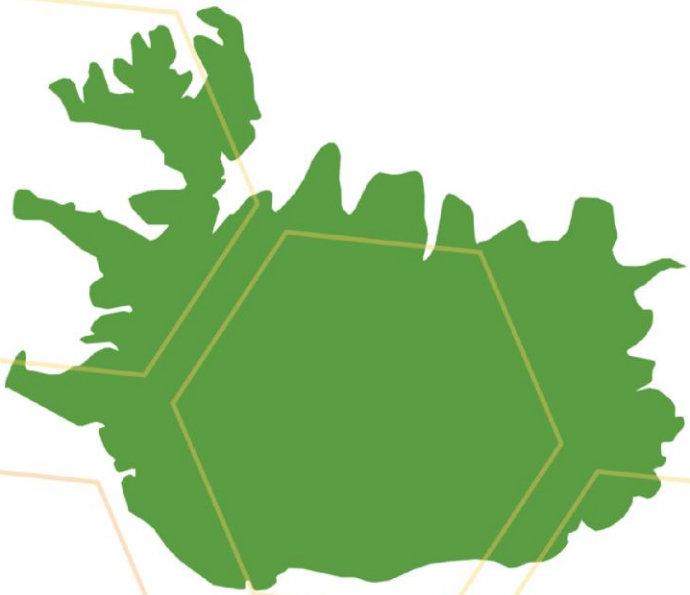
Iceland



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Costs and economics

- LCOE – Average LCOE is from $35 – 38/MWh
- CAPEX Total $2.9/MW
- OPEX is 3% of construction cost

Support Schemes

N/A

Government Allowances and/or Exemptions

N/A

Funding available for Capital Costs

There is no specific funding scheme for geothermal projects, but it is possible to apply for funding or loans through the Orkusjóður energy fund.

Technology suppliers, products and services they offer

Developer	Services	Contact Information
Landvirkjun	Produces 71% of electricity power in Iceland	Landsvirkjun Háaleitisbraut 68 103 Reykjavík Iceland Tel: +354 515 9000 andsvirkjun@landsvirkjun.com Open from 8:30 - 16:30
HS Orka	Produces 7% of electricity power in Iceland	HS Orka hf Svartsengi 240 Grindavík Tel: 00354- 520-9300 Email: hsorka@hsorka.is

Fallorka/Orkusala	Produces combined 3% of electricity power in Iceland	FALLORKA EHF RANGÁRVELLIR 603 AKUREYRI Tel: 00354 -4601380 E: FALLORKA@FALLORKA.IS
Orka Náttúrunnar	Produces 19% of electricity power in Iceland	Orka náttúrunnar on@on.is Bæjarhálsi 1, 110 Reykjavík Þjónustuver: 00354-591 2700 open all week from 8:00 to 16:00 Grænt númer: 800 1900

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Tel: +353 (0)94 986 1441
Email: paulineleonard@wdc.ie

Project Partners
GREBE will be operated by eight partner organisations across six regions:

WDC Western Development Commission

Action Renewables – the future of energy, today

Luke Natural Resources Institute Finland

FPN Forskningsparken i Narvik

eri environmental research institute

Fermanagh & Omagh District Council
Comhairle Ceantair Fhear Manach agus na hÓmaí

Innovation Center Iceland

Karelia

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