Geothermal Energy Utilisation - Ireland Country Update

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Keywords: Ireland, country update, geothermal, shallow, heat pumps, low enthalpy.

ABSTRACT

Geothermal energy in Ireland is dominated by the exploitation of low temperature resources for space heating using heat pumps. The last country update in 2010 showed domestic ground source heat pumps installations for space heating and domestic hot water as the principal application primarily as a result of government support through dedicated grant schemes towards the capital investment costs of installations.

The marked rate of increase reported in the number of heat pump units installed in Ireland up to 2010 accounting for up to 164MW installed capacity from ground source alone has now declined. The currently difficult economic situation and the end of the dedicated financial support for domestic ground source heat pumps has resulted in very few systems being installed during 2011 and 2012, with the main deployment attributed to large scale open and closed loop ground source systems with individual installed capacities of up to 2MW in size.

Since the initial exploration drilling on the southern margin of the Dublin Basin, the deep geothermal energy sector has progressed very slowly. Despite encouraging results from 2D seismic reflection surveys at the Newcastle project and planning for the first deep geothermal electricity plant being granted in late 2010, the lack of subsidies for geothermal electricity generation and the holdup in the implementation of a legislative framework for licensing deep geothermal resource exploration and development have stalled the sector. Extensive research aimed at better understanding deep geothermal resources in different geological settings in Ireland is being undertaken.

A number of initiatives to stimulate a sustainable future development of the shallow geothermal energy sector in Ireland are being implemented. These are aimed at tackling some of the barriers to the future development of the geothermal sector that have been identified. Technical guideline documentation and new interactive mapping of the shallow geothermal resources and their potential for deployment in Ireland are being developed with a view to providing standards for system installation and increasing public awareness amongst users and local authorities about shallow geothermal energy potential. The structure of a national database of ground source systems is being developed with a view to improving the reporting of shallow geothermal energy installations in Ireland. New comprehensive training initiatives and certification for industry stakeholders involved in design and installation of systems are currently being undertaken.

1. INTRODUCTION

The thermal energy market in Ireland (excluding energy produced from electricity for space heating) accounts for 34% of the gross final energy consumption in 2011, with 47% of the thermal energy usage accounted for by the residential sector. The contribution of the RES-H sector in Ireland stands at 4.8% in 2011 when a national target of 4.9% was set for 2010 (SEAI, 2011).

The National Renewable Energy Action Plan (NREAP) for Ireland (DCENR, 2010) sets targets for the energy produced from heat pumps (including geothermal, aerothermal and hydrothermal) of 84 ktoe by 2020 with an expected average increase of between 6 to 7 ktoe (Table 1). No deep geothermal targets for renewable heating and cooling have been included and a target of 5MW$_e$ installed capacity by 2018 with no additional increase by 2020 has been set.

Table 1:Extract from the NREAP - Ireland, Renewable Energy from Heat Pumps (ktoe) including aerothermal, geothermal& hydrothermal (DCENR, 2010).

Year 20'	10	11	12	13	14	15	16	17	18	19	20
ktoe	18	25	31	38	44	51	58	64	71	78	84

The first progress report results for energy from heat pumps for 2009 and 2010 (Table 2) suggests that energy produced from heat pumps in Ireland was ahead of targets for this period despite industry market sector figures showing a higher potential contribution.

Table 2:Extract from the NREAP - Ireland, First Progress Report, Renewable Energy from Heat Pumps (ktoe) including aerothermal, geothermal& hydrothermal (DCENR, 2012).

Year	2009	2010
ktoe	22	23

The NREAP targets set for the total contribution for district heating and cooling from renewable energies is outlined in table 3 below. The recent NREAP progress reports suggest that little or no contribution is being met through district heating.

Table 3:Extract from the NREAP - Ireland, district heating and/or cooling from total renewable heating and cooling consumption (DCENR, 2010).

Year 20'	10	11	12	13	14	15	16	17	18	19	20
ktoe	0	16	29	43	56	70	83	96	110	123	131

The Strategy for Renewable Energy 2012-2020 (DCENR, 2012) identified district heating as one of the technologies for addressing the heat energy demand in Ireland and meeting renewable energy targets.

Despite not being specifically identified as one of the preferred technologies in current government strategy documents, geothermal energy has a significant role to play in contributing to the roll out of district heating in Ireland and the extent of this contributions may be further developed following the ongoing review of the national Climate Change Strategy (in press).

2. GEOTHERMAL RESOURCES IN IRELAND:

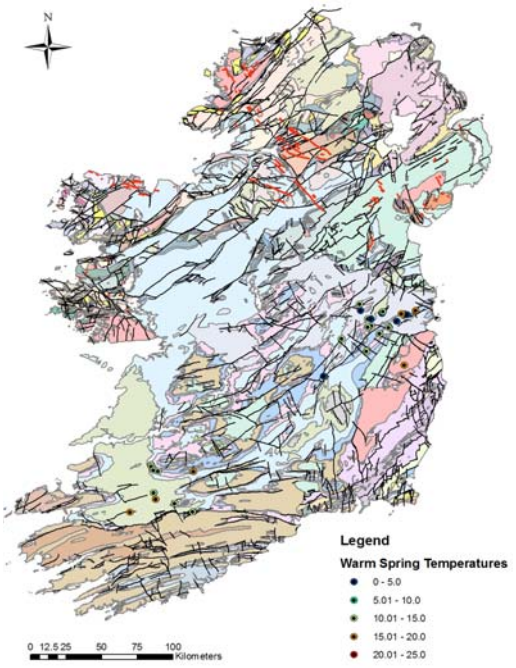
Ireland is characterised by Precambrian to Lower Palaeozoic crystalline basement formations overlain for most of the central part of Ireland by Upper Palaeozoic formations of Upper Devonian and Lower Carboniferous age and comprising shales, limestones and sandstone lithologies (figure 1). Karstification of the Lower Carboniferous lithologies is extensive and for the most part buried due to a relatively thick Quaternary aged overburden cover.

The structural geological conditions in Ireland are controlled by the Caledonian and Variscan orogenies. Both of these events resulted in the development of large scale north-east south-west trending fault structures parallel to the Iapetus Suture and similar east west trending structures along the northern boundary of the Variscan front in the south western part of the country.

The presence of 42 warm springs across Ireland is largely associated with the occurrence of these regional fault structures concentrated in areas to the south of the Iapetus suture zone where Lower Carboniferous lithologies are present.

Temperatures of between 13°C and 24.7°C from the warm springs have been recorded as part of extensive research since the early 1908s. Hydrochemical and isotope studies have demonstrated that whilst there is evidence of deeper than average circulation of groundwater occurring as a result of up to ten geological settings of the warm springs (Aldwell & Burden, 1986), these deep circulation pathways remain poorly understood.

Figure 1: Bedrock Geological Map of Ireland (GSI, 2006)& location of warm springs.

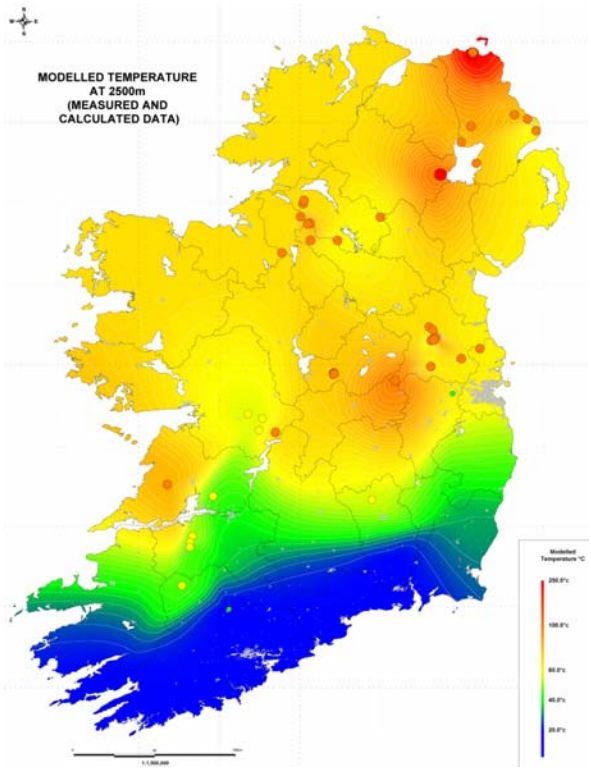


Ireland's intraplate geological setting is such that geothermal resources are classified as low enthalpy with lower average geothermal gradients of approximately 10°C/km recorded in the south to higher gradients (figure 2) in the north east and in Northern Ireland where values of up to 35°C/km are observed (Goodman *et al.*, 2004).

Northern Ireland has a number of sedimentary basins. The Mesozoic Rathlin, Larne and Lough Neagh Basins have been explored in the past because of their potential to contain oil and gas reserves and as part of early geothermal energy research projects by the UK Department of Energy. These three basins contain in excess of 3000m of Permo-Triassic sediments (McCann, 1991) where the highest measured temperatures at depth have been recorded. The North-West Basin in the southwest of Northern Ireland contains a similar thickness of Carboniferous sandstones, shales and lime-stones (Mitchell, 2004).

Shallow geothermal energy resources are favour by the Irish climate that is dominated by warm and mild maritime conditions. Relatively consistent, year round soil temperatures and frequent rainfall keeping moisture in the ground maintains soil as an excellent conductor, allowing heat to move towards a thermal collector system. These conditions are particularly suited for horizontal closed loop systems.

Figure 2: Modelled Temperature at 2,500m (Goodman, *et al.* 2004).



2 SHALLOW GEOTHERMAL ENERGY DEPLOYMENT:

The shallow geothermal energy sector in Ireland had a very high growth rate until 2009. The installed capacity for geothermal heating and cooling in Ireland in 2010 totalled 164 MW_{th} installed capacity and 744 TJ/yr energy usage from ground source heat pumps (Allen, & Burgess, 2010). Cooling accounted for a total of 6.6 MW_{th} installed capacity and 13.34 TJ/yr annual energy use in 2010.

The lack of a dedicated database for reporting the number and characteristics of installation of shallow geothermal energy systems in Ireland, has made it difficult to determine exactly both the market conditions in terms of the contribution of ground source heat pumps to renewable heating and cooling at a national level and the increase in installed ground source systems since the detailed data collected since 2009.

Figures published by the Heat Pump Association of Ireland in 2012 show a total cumulative number of installed units on 17,014 in 2011, however this does not differentiate between geothermal and air source heat (Table 3).

Table 3: Heat Pump Installations in Ireland (HPAI, 2012).

Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Residential										
New Units	546	990	1300	1900	2205	2673	2751	922	1293	989
Cumulative Units	546	1536	2836	4736	6941	9614	12365	13287	14580	15569
Total Installed Capacity (MW)	**8**	**23**	**43**	**71**	**78**	**117**	**148**	**162**	**178**	**190**
Commercial										
New Units	5	10	50	100	220	268	306	103	144	239
Cumulative Units	5	15	65	165	385	653	959	1062	1206	1445
Total Installed Capacity (MW)		**1**	**2**	**7**	**15**	**25**	**38**	**42**	**48**	**57**
Total										
New Units	551	1000	1350	2000	2425	2941	3057	1025	1437	1228
Cumulative Units	551	1551	2901	4901	7326	10267	13324	14349	15786	17014
Total Installed Capacity (MW)	**8**	**24**	**45**	**78**	**93**	**142**	**186**	**204**	**226**	**247**

The shallow geothermal energy market in Ireland remains dominated by the installations in the residential sector (85%) with lower uptake in the commercial and industrial processes sector (14% and 4% respectively) with systems of intermediate installed capacity between 10kW and 20kW installed as the most widespread (Figure 3a &3b).

A recent survey of shallow geothermal energy system installers in Ireland (Allen *pers. comm.*) suggests that very few ground source systems were installed during 2012, with the majority of the additional national heat pump installed capacity being met through the use of air source heat pump technology. Aside from the large commercial ground source systems installed since 2010, the number of residential systems has increased only marginally since the estimate of 9,500 systems installed in 2010 (Allen, & Burgess, 2010).

Figure 3a: Average Ground Source Heat Pump Installed Capacity (SEAI, 2011).

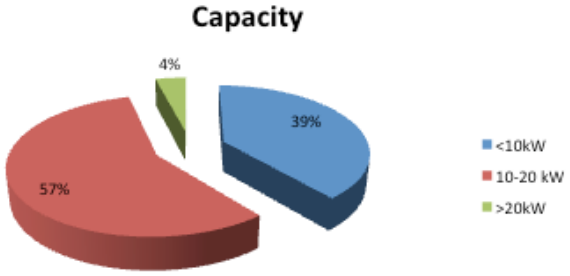
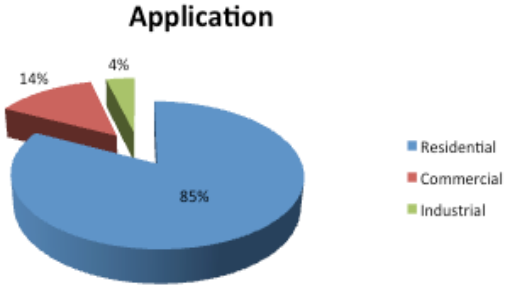


Figure 3b: Ground Source Heat Pump Application (SEAI, 2011).



Large scale, ground source systems are dominated by the installation of open loop collectors, with the majority of systems being installed ranging between 100kW to 250kW in size for heating and cooling applications. The completion of more recent larger scale systems with installed capacities >1MW have become more frequent, with some of these including closed loop multiple borehole collectors (Table 4).

An example of one of these is the Athlone shopping centre, comprising an open loop system comprising of 13 wells drilled to a depth of 70m in gravel of which 8 wells are used to deliver up to 167 l/s with the rest used for re-injection. The system is used for space heating and cooling using a district heating scheme (figure 4).

The cooling load peak is 1,870kW for the shopping centre and 900 kW for the hotel. Discharge water is returned to the gravel beds through recharge wells located around the perimeter of the basement carparks. The system is monitored and controlled by a Building management System which has the ability to archive key operating parameters and energy flows (Allen *et al.* 2013).

Figure 4: Athlone Shopping Centre Plant Room (Allen, 2013).

Table 4: Major GSHP Installations in Ireland (Jones, 2011). (H - horizontal, VOL- vertical open loop, WOL - Well Open Loop *No.* of boreholes & depth in *m*).

Locality	County	Floor area m^2	Ground / water temp.	HP Thermal Htg / Clg Capacity kW	Collector Type	Flow rate	COP
Green Building, Temple Bar 1994	Dublin			23	V CL 150m		4.87
100-250kW							
Cowper Care, Kilternan	Dublin	2,000	8	80	V CL 12BH x 170m		3.5
Tralee Community Nursing Unit	Kerry		11	100	V		3.5
Oilgate Nursing Home			8	100	V		3.5
Mallow Swimming Pool 1987	Cork	Preheat	15°C	100	V OL 75m		4
Offaly Co. Co. Offices, Tullamore	Offaly	5,100	10	105 H&C	V OL 4 BH	6.6l/s	3.05
Hotel Europe, Killarney	Kerry		10	110	W ??		3.5
SHARE Hostel 2002	Cork City	1,200	15	120	W OL 1BH x 18m		3.5
Cliffs of Moher Visitor Centre	Clare		10	120 H 150 C	H 6km	N/A	3.5 – 4.5
Tralee Motor Tax Office 1999	Kerry	1.178	10	130	H 5.1km	N/A	3.7 – 4.5
Hudson Bay Hotel, Athlone	Westmeath		11	132	W		3.5
Brook Lodge Hotel	Wicklow		10	134	H	N/A	3.5
Castleisland	Kerry	1,500	11	135	W OL	6.5l/s	3.5
Glenstal Abbey	Limerick		6 - 10	150	W OL (small lake)		3.5
Musgrave HQ	Cork City	2,100	10	160 H&C	V CL 12 x 120m		3.65 to 4.5
Killorglin Town Centre	Kerry	2,200	11	160 H&C	W OL 2BH x120m		3.65 (to 7)
Fermoy Leisure Centre	Cork	1,200	11	165	W OL 2 x 15m		3.5
UCC Glucksman Gallery	Cork City	2,350	15	220 H&C	W OL 2 BH x 12m	10l/s	3.65 (to 7)
Vistakon (Sisk)	Limerick City			C	V OL 3 BH x 50m		
Portadown Community Health	Armagh			H&C	Piles	N/A	
250kW-1MW							
ESB Administration Offices	Cork City	2,000	13	250 H&C	W OL	10l/s	3.65
Belinter Hotel, Navan	Meath	??	10	306	H	N/A	3.65
Fexco HQ, Killorglin	Kerry	3,900	11	310 H&C	W OL 3BH X 120m		3.65 (to 7)
Vista Health Care, Naas	Kildare		10	400	W OL 2 BH		3.65
Cork County Library	Cork	2,800	13	450 C	W OL	13l/s	4.00
Treacys Hotel	Wexford		11	450	V OL		3.65
>1MW							
Royal Victoria Hospital, Belfast	Antrim			1000 H&C	V OL 3 BH x 100m		
UCC Western Gateway IT Building	Cork City		15	1000 H&C	W OL BH/ surface		3.65
Athlone City Centre Retail Complex	Westmeath	28,000	10	1876 H &C	W OL 3 BH	90l/s +	3.65
IKEA store, Ballymun	Dublin	30,598		2000 H&C	V CL 158 BH x 90m		

The Vistakon geothermal heat rejection plant in Limerick is another example of a recent large scale open loop commercial system installation in Ireland. The project involves the use of groundwater as a cooling resource to minimise electrical load demand, save energy and reduce carbon dioxide emissions. It involves abstraction of some 30l/s (2,592 m^3/day) of groundwater from two on-site boreholes. The water is used in a once-through, non-product contact, cooling system and recharged to the local river system (Jones, 2013).

The IKEA store in Ballymun (Dublin) opened in late 2010 is one of the first operating examples of a large closed loop commercial system being installed in Ireland. The ground source collector comprises 158 boreholes drilled to a depth of 90m located below the customer car park. The system provides heating and cooling to the 30,600m^2 store and has a total installed capacity of 2 MW_{th} (Finnegan, 2011).

3. DEEP GEOTHERMAL ENERGY DEPLOYMENT:

Deployment of deep geothermal energy resources in Ireland has been slow to date. Since the completion of geothermal exploration wells in 2009 by GT Energy in Newcastle, South County Dublin, the potential for harnessing deep geothermal resources from the margin of the Dublin Basin has been further explored. A 2D seismic reflection survey (figure 5) and a VSP survey undertaken in late 2010 with the support from the Sustainable Energy Authority of Ireland helped identify potential reservoir targets at the base of the Carboniferous sequence at a depth of 4,000m, with the best of these located along the northern margin of the Blackrock to Newcastle Fault line. On the back of these results, GT Energy applied for planning permission for a 4.5 MW geothermal electricity plant at Newcastle. The proposed geothermal electricity plant comprises a production and a re-injection well as well as an air cooled, modular, Organic Rankine Cycle plant.

Figure 5: 2D Seismic Acquisition in Newcastle, South County Dublin.

Since planning was granted for the project in late 2010, the lack of a REFIT tariff for geothermal electricity generation and the lack of a suitable legislative and regulatory framework for the development of deep geothermal energy resources, has prevented the project from progressing beyond the planning stage.

The Geothermal Play Fairway Analysis study (Goodman *et al.*, 2011) profiled the geothermal resource development risk in different basin areas of Ireland. This 'All Island' study highlighted the presence of basin areas as having low geothermal energy development risk. These include three Mesozoic Basins in Northern Ireland (Rathlin, Lough Neagh and Larne) and18 Carboniferous Basins and Sub-basins of the midlands, east, west and south west of Ireland (East Dublin Basin, Portarlington Trough, Dangan Trough, Clare Basin, Limerick Basin, North Cork Mallow Basin, Carrick-on-Suir Syncline, West Leinster Basin). These areas were highlighted as having the greatest geothermal potential where hot fluids have migrated a relatively short distance from a deep geothermal heat source and are trapped in Mesozoic and Carboniferous reservoirs overlain by an insulating cover of shaley or other low conductivity rock types.

Geothermal potential from buried granites, with sufficient insulating cover rocks was also identified and a lower development risk category was attributed where deeply penetrating and suitably fractured major structural zones that may have acted as migration pathways for deep hydrothermal fluids from a deep heat source to a shallower geothermal reservoir.

Some of the areas identified are the subject of more extensive research being undertaken by the IRETHERM project.

4. LEGISLATIVE AND REGULATORY FRAMEWORK:

4.1 Geothermal Development Bill:

The Draft Geothermal Development Bill (the Bill) defines geothermal energy in Ireland and vests ownership of geothermal energy in the State, giving practical effect to the assertion of ownership of natural resources in the Constitution (King, 2011). The Bill covers the exploration and development of deep geothermal energy resources in Ireland (excluding aspects such as district heating, market regulation and health and safety).

An extensive consultative process started in 2008 in advance of the drafting of the general scheme of the Bill and included web-based consultations, two national workshops and meetings with industry stakeholders.

The proposed Bill focuses on the following principal topics:

- licensing of exploration and development operations;
- the right to access third party lands;
- ancillary rights in respect of the portion of the subsurface of land that lies 10 metres or more below the surface;
- the appointment of the Mining Board as the Arbitrator;

- the provision in the regulations for the collection of geothermal installation information for a publicly available register;
- exemption of small scale-domestic systems.

Draft Heads of the Bill completed in July 2010 have been submitted to the Government for approval and referred to the Attorney General and the Parliamentary Counsel for detailed drafting alongside the proposed new Minerals Development Bill. This consultation process is ongoing and publication of the Bill is expected in the near future.

4.2 Shallow Geothermal Energy Resource Project

The Groundwater Section of the Geological Survey of Ireland (GSI) has been involved with geothermal resources since the 1960s. In the last two decades, GSI's Groundwater Section's involvement with geothermal resources has been to a much lesser extent as its focus has been on protecting the quality and sustainability of groundwater drinking water supplies. For the last five years, however, the Groundwater Section has been increasingly involved with geothermal resources. The aim of the shallow geothermal energy project is to provide a sustainable platform for development of the ground source heat pump sector in Ireland through collaboration with government departments and agencies, geothermal industry stakeholders (e.g. Geothermal Association of Ireland, International Association of Hydrogeologists - Irish Group, Heat Pump Association of Ireland), local authorities, appropriate academic institutes and consultants (e.g. geological drilling, hydrogeological, architects).

In line with other ongoing European initiatives, the first part of the project is aimed at developing a national database of installed ground source heat pump systems. The objective of these data will be to characterise existing operating heat pump installations and to provide a framework for recording future heat pump installations and their associated subsurface collectors.

Two guideline documents are being prepared by the GSI. These are expected to cover the sub-surface aspects of shallow geothermal energy installations for horizontal collectors and vertical collectors and their construction.

A technical guideline manual for system completion, to address adequate methodologies and procedures for suitably trained professionals to install shallow geothermal energy systems in the context of the current environmental and building regulations, is currently being developed. The manual is intended to cover the completion of the collector and subsurface parts of shallow geothermal energy systems with recommendations on project development and management methodologies.

A homeowner manual is also currently being developed by the GSI to assist home owners with the choice of shallow geothermal energy systems installation, and to provide advice on procedures and methodologies that would be associated with each phase of installation. This manual will also provide case study examples showing the benefits of shallow geothermal energy systems compared to other renewable and fossil fuel fired heating systems.

The final phase of the project will focus on developing a set of collector suitability maps for closed loop horizontal, closed loop vertical and open loop collectors. The maps will be generated using subsurface data currently available at the GIS and in collaboration with other government agencies and research institutions that are compiling geothermal resource information. The databases will also aim to integrate information compiled as part of the development of a national shallow geothermal installations database.

5. BARRIERS TO DEPLOYMENT:

Financial support mechanisms that were in place for the installation of domestic geothermal heating systems were withdrawn. The unforeseen immediate cessation of this financial support resulted in a marked decrease of domestic system installations and unfortunate closure of many geothermal energy installation businesses. Current financial support measures specific to GSHPs are currently not available.

The introduction of the carbon tax which places an extra cost on fossil fuels such as gas or oil, the payback period for installation of geothermal pump heating systems is reducing considerably..

In addition, the improvement in performance of heat-pump technologies, are further reducing payback periods to less than 10 years for systems that replace oil or LPG fuelled heating (Burgess 2011).

Financial support for geothermal electricity generation has still not been considered by government through the REFIT scheme despite a target of 5 MW_e installed capacity by 2020 being set as part of the NREAP for Ireland.

The main barriers to the development of geothermal energy resources in Ireland remain the lack of specific legislation allowing developers to obtain licenses for resource exploration and development. The Draft Geothermal Development Bill has been drafted and reviewed by the attorney general. However further progress on the legislation and a subsequent regulation has not advanced since 2011.

The lack of technical best practice guidelines for the installation of shallow geothermal energy systems in Ireland is currently being addressed by the Geological Survey of Ireland. This will facilitate the sustainable development of shallow geothermal energy resources in Ireland.

Public Awareness and information including the lack of information on the potential for installing ground source heat pumps and potential for harnessing deep geothermal energy to meet a part of Ireland's heat demand has been identified as a significant barrier to development. Despite some guidance documents from SEAI being made available to explain the use of the technology, not many data are available to promote subsurface conditions that are adequate for the deployment of GSHP systems. Similarly, several studies have been completed on the deep geothermal potential and on-going research through the IRETHERM project aims to provide a better understanding and promotion of Ireland's deep geothermal potential.

This information is essential to both the end users and the general public, but also to the local authorities and government agencies who are tasked with setting strategic local and national objectives for the deployment of shallow and deep geothermal resources alike. The GSI is currently in the process of developing a set of collector suitability maps based on existing information and the inclusion of data from already installed and operating systems as part of the shallow geothermal energy project. This information is expected to be publicly available through the GSI online data viewer, facilitating the understanding of the potential for deployment of geothermal resources.

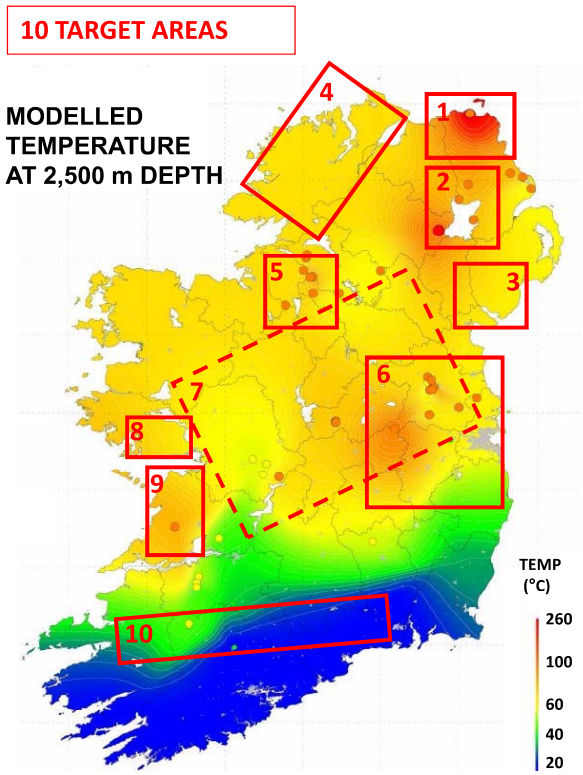
Dedicated training and certification for key contractors involved in the installation of GSHP systems is currently being undertaken through the FETAC level 6 certification scheme. This allows trades such as plumbers, electricians and refrigeration engineers to be trained and certified to install shallow geothermal energy systems. However there are no dedicated training or certification courses for contractors responsible for the design, completion of ground works and drilling associated with the completion of thermal energy collectors.

Dedicated courses on project management and ground source heat pump system design are only available through dedicated university courses at Galway Mayo Institute of Technology, University College Cork and University College Dublin. However professional certification for trades, often tasked with designing systems or involved in the construction aspects of ground source heat pump systems, is currently not available. The Geotrainet programme to some extent fulfilled this role by providing an integrated training initiative for installers, drillers and designers. However a new national certification training initiative combined with the Geotrainet + programme will be required to promote a sustainable development of the shallow geothermal energy sector in Ireland.

6. ON GOING RESEARCH & PROJECTS:

The IRETHERM project is a four and a half year, all island, academic-government-industry collaborative project between DIAS, UCD, UCC, GSI, GSNI, and SLR Consulting to develop a strategic and holistic understanding of Ireland's geothermal energy potential.

Figure 6: IRETHERM Target Areas (Muller *et al.*, 2012 & Goodman, 2004).



The project aims to deliver integrated models of new and existing geophysical and geological data to image aquifers and granitic bodies in the depth range of 0 to 5 km. The project is focussing on eight "type" geothermal areas across 10 targets (figure 6) with a comprehensive program of electromagnetic field surveys to identify those geological settings/localities that present the greatest opportunity for harnessing deep geothermal energy. These include:

- the Permo-Triassic Basins of Northern Ireland,
- radiogenic granites,
- warm-spring lineaments
- high heat-flow/temperature anomalies recorded as part of compiled in the Geothermal Energy Resource Map of Ireland,
- deeply penetrating, significant fault zones,
- gravity anomalies of unknown origin,
- areas of current seismicity,
- basal sediments of the Carboniferous and Devonian successions.

New borehole temperature and heat flow measurements and analyses of radiogenic element compositions of an island wide suite of multi-depth crustal samples are being undertaken to derive the first 3-D model of Irish crustal heat production. Thermal variations modelled using these new crustal heat production constraints with existing constraints on lithospheric structure will determine the origin of the regional variation in heat flow and identify high

temperature anomalies at upper crustal levels for immediate and future targeting.

Two initial field campaigns in 2011 and 2012 have yielded promising results for some of the 10 areas targeted and further results are expected during the course of 2013 once the new data have been integrated and modelled.

The NAG-TEC project is a co-operation between Geological Surveys and oil companies (Northeast Atlantic Geoscience - NAG initiative) aimed at developing a new Tectono-stratigraphic Atlas of the North-eastern Atlantic. This will address the tectonic development of the Northeast Atlantic in a unified manner. The data compilation will deliver a quantitative analysis of key basin parameters, the regional correlations of key stratigraphic units, unconformities and geologic formations, an understanding of the connectivity and similarities between known prospective regions and unexplored areas, as well as a comprehensive analysis of conjugate margin pairs. The analysis of these basin parameters includes a study of heat flow and temperature distribution across the region. Historical heat flow values for onshore Ireland were compiled as the Geothermal Energy Resource Map of Ireland Atlas (Goodman *et al.*, 2004) and are currently the subject of further research by the IRETHERM consortium. The NAG-TEC project is undertaking studies of temperature data from 18 offshore oil exploration wells, with the hope that new heat flow data can be produced for offshore Ireland. These data will then be incorporated into a regional compilation as a chapter in the Atlas and result in a series of maps, most likely with the following information: heat flow, temperature at 1,000m, temperature at 2,000m, thermal gradient and data coverage (Judge, 2013).

The REGEOCITIES project kicked off in May 2012 and is aimed at removing the legal and regulatory barriers to the application of geothermal heat pump systems in Europe. The project intends to build on existing knowledge and experience of EU Member States where the geothermal heat pump sector is mature (Germany, France, Denmark, Sweden) and develop general guidelines and recommendations for policy and regulation of geothermal energy systems in European cities, regions and Member States. Smoother policy should contribute to European sustainability objectives and help Member States achieve 2020 renewable energy targets. As part of the first year of the project an analysis of the market conditions and the regulatory framework for shallow geothermal systems in Ireland has been undertaken. The project has organised a national workshop for target stakeholders including policy makers, government agencies and local authorities to identify the perceived barriers to the development of the sector in Ireland. This process is on-going and further individual consultations with local authorities will be undertaken in 2013. As part of the project objectives, Regeocities will deliver recommendations for a common regulatory framework template for shallow geothermal systems and provide a database structure for recording the installations of systems. It will also facilitate the reporting of the contribution from shallow geothermal energy as part of the NREAP targets as well as the inclusion of shallow geothermal energy as part of Sustainable Energy Action Plans and Renewable Energy Strategies. Dedicated training programmes for policy makers and local authorities will be delivered during 2014.

The GeoDH project is focussing on increasing the market penetration of geothermal district heating systems in several Member States analysing the market conditions in countries with a mature geothermal district heating sector such as Germany, France, Italy and transition countries where there is a growth in the sector such as Hungary, Slovenia, Slovakia, Czech Republic, Poland, Denmark. Then using the experience from these countries to facilitate development in new upcoming markets such as Netherlands, UK, Ireland, Bulgaria, Romania. The project is aimed at promoting the use of geothermal energy sources through district heating and cooling systems by proposing the removal of regulatory barriers, developing innovative financial models and by training technicians and increasing awareness among decision-makers. The objectives of the project include: increasing awareness on the potential for application as well as to demonstrate benefits of district heating and cooling with geothermal energy, to develop a set of recommendations for removing barriers, to improve regulatory frameworks, to provide a better understanding of related technologies, costs and financing, and transfer best practices to national and local authorities through dedicated workshops. A stakeholder workshop in the first part of 2013 has highlighted the lack of strategic objectives with regard to geothermal energy and district heating, the lack of regulation of the heat market, the lack of financial support for the deployment of district heating and the lack of support for development of deep geothermal heat in Ireland as being the main barriers to both technologies.

The Tellus Border project is an EU Interreg IVA project in the in the border counties of Donegal, Sligo, Leitrim, Cavan, Monaghan and Louth using coupled airborne geophysical and ground based geochemical surveys for mapping the geological environment. The data from the Tellus Border project will be combined with the previously acquired Tellus data in Northern Ireland to produce Ireland's first cross-border geo-environmental maps to support sustainable management of the environment and natural resources, including geothermal energy. Radiometric survey results previously acquired in Northern Ireland identified elevated concentrations of radionuclides K, Th, U in the Mourne Granites and how calculated radiogenic heat localised in the area shows potential for a deep hot dry rock geothermal source (Glennon *et al.*, 2012). The new Tellus Border geophysical magnetic and radiometric data was released on 5th

February of this year. Topsoil geochemical data is available to view from the Tellus Border viewer and will be released for download throughout 2013 (Glennon, 2013).

Research and Development in Expanding Gas Power Transformation (EGPT) is being led by Irish geothermal energy specialists who have undertaken key research on this process using a new heat pump cycle (EGPT, 2012). This new system has won a Sustainable Energy Innovation Award from Sustainable Energy Ireland in 2012.

In 2011, an all Island (North and South) competition was held to find the domestic installation of the year. The GAI organised and held this competition to promote those examples of geothermal energy installations that were operating effectively and providing comfort to the home-owners. There were 4 installations deemed worthy of recognition and the benefits were measured and benchmarked with reference to the Building Energy Rating system in place for homes in Ireland. (Burgess 2011). A similar competition is being held in 2013 but for non-domestic installations to promote excellence in the industry. The winners will be announced on 13th November at the third Geothermal Energy conference to be held in Ireland. This conference will also showcase leading research in geothermal energy.

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Acknowledgements

A special note of thanks to Paul Sikora, James Byrne, Monica Lee, and committee members of the Geothermal Association who assisted in submitting updates and compiling data for the completion of this country update.

Tables A-G

Table A: Present and planned geothermal power plants, total numbers*

*Geothermal power plants are not available in the country.

Table B: Existing geothermal power plants, individual sites*

*Geothermal power plants are not available in the country.

Table C: Present and planned geothermal district heating (DH) plants and other direct uses, total numbers*

*Geothermal district heating plants are not available in the country.

Table D: Existing geothermal district heating (DH) plants, individual sites*

*Geothermal district heating plants are not available in the country.

Table E: Shallow geothermal energy, ground source heat pumps (GSHP)

	Geothermal Heat Pumps (GSHP), total			New GSHP in 2012		
	Number	Capacity (MW_{th})	Production (GWh_{th}/yr)	Number	Capacity (MW_{th})	Share in new constr. (%)
In operation end of 2012 *		169	225			
Projected by 2015		185	245			

* end of 2011 figures

Table F: Investment and Employment in geothermal energy **

	in 2012		Expected in 2015	
	Investment (million €)	Personnel (number)	Investment (million €)	Personnel (number)
Geothermal electric power		5	5	8
Geothermal direct uses		5		8
Shallow geothermal	17.3	60	25	80
total	**17.3**	**70**	**30**	**96**

** Estimates based on figures published at WGC2010

Table G: Incentives, Information, Education

	Geothermal el. power	Geothermal direct uses	Shallow geothermal
Financial Incentives – R&D	Science Foundation Ireland is funding the 4 year IRETHERM project which undertaking active research on the deep geothermal potential of different geological settings in Ireland	Science Foundation Ireland is funding the 4 year IRETHERM project which undertaking active research on the deep geothermal potential of different geological settings in Ireland	N/A
Financial Incentives – Investment			N/A
Financial Incentives – Operation/Production			N/A
Information activities – promotion for the public	No	No	Yes - SEAI have dedicated information on ground source heat pump technology
Information activities – geological information	Yes - SEAI geothermal atlas of Ireland & a Geothermal Play Fairway Analysis	Yes - SEAI geothermal atlas of Ireland	Under development - The Geological Survey if Ireland is developing a set of technical guideline documents, a home owner manual and a set of ground source heat pump suitability maps
Education/Training – Academic	No	No	Yes - Several courses on project management and GSHP design
Education/Training – Vocational	No	No	Yes - National certification for installers

Key for financial incentives:					
DIS	Direct investment support	RC	Risc coverage	FIP	Feed-in premium
LIL	Low-interest loans	FIT	Feed-in tariff	REQ	Renewable Energy Quota