Geothermal Energy Use, Country Update for Ireland

Riccardo Pasquali[1], Gareth Ll. Jones[1], John Burgess[1] and Taly Hunter Williams[1]

[1] Geothermal Association of Ireland, c/o SLR Consulting, 7 Dundrum Business Park, D14 N2Y7, Ireland

rpasquali@geoservsolutions.com

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ABSTRACT

Geothermal energy resources in Ireland are of low enthalpy in nature, with the main exploitation focussed on the use of ground source heat pumps. Following an initial surge in the number of mainly domestic ground source heat pumps installed up to 2008, the annual rate of increase in installations has slowed considerably.

A slow increase in the number of heat pump units installed of about 3% per annum between 2010 and 2015, accounts for a total of 191 MWt installed capacity (a 14 MWt increase from the WGC 2015 report). The main deployment is attributed to larger scale open and closed loop ground source systems with a reduction in small domestic installations.

Since the initial exploration drilling on the southern margin of the Dublin Basin, the deep geothermal energy sector has little progressed. The lack of clear policy with respect to the development of deep geothermal resources in Ireland and the delayed implementation of a legislative framework for licensing deep geothermal resource exploration and development have stalled the sector. The completion of extensive research aimed at better understanding deep geothermal resources in different geological settings in Ireland has highlighted the potential for deep geothermal energy for direct uses to be developed. However a further need for research of key areas including the Dublin Basin and Northern Ireland as well as the need for the completion of a deep demonstration borehole are required.

A number of initiatives to stimulate a sustainable future development of the shallow geothermal energy sector in Ireland have been implemented. These include new interactive collector suitability maps for shallow geothermal systems and their potential for deployment in Ireland. The objective of these maps is to increase public awareness amongst users and local authorities about the shallow geothermal energy potential. The completion of guideline documents for end users and professional involved in the installations of the ground source sector have been developed. New comprehensive training initiatives and certification for industry stakeholders involved in design and installation of systems are currently being undertaken.

1. INTRODUCTION

The demand for heat energy was the largest source of energy use in 2012, accounting for 45% of all primary energy and 33% of CO_2 emissions. Space and water heating in residential dwellings and the services sector account for over 60% of heat demand, with process heat in the industrial sector accounting for over 30% of such demand (SEAI, 2015).. The contribution of the RES-H sector in Ireland reached at 6.6% in 2014, with a national target of 12% set for 2020 (SEAI, 2016).

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. No deep geothermal targets for renewable heating and cooling have been included and a target of 5MWe installed capacity by 2018 with no additional increase by 2020 has been set.

The 2015 progress report shows that results for energy from heat pumps for 2014 suggests that energy produced from heat pumps in Ireland has fallen behind of the set target for 2014 of 51 ktoe, with a total energy produced from heat pumps estimated at 38 ktoe only (DCENR, 2015).

The target contribution for district heating and cooling from renewable energies projects is 131 ktoe by 2020, with a target of 56 ktoe by 2014. The 2015 NREAP progress report shows no contribution is being met through district heating.

The contribution of renewables to the RES-H sector reported for 2014, requires a significant increase in the deployment equivalent to the 300,000 homes, 3,000 services/public sector buildings or 200 large industrial sites installing a renewable heating technology for heating and cooling (SEAI, 2016).

The Energy White Paper 2015-2020 (DCENR, 2015) identifies geothermal energy, heat pumps and district heating as technologies for addressing the heat energy demand in Ireland and meeting renewable energy targets.

The paper also makes provision for the implementation of a Renewable Heat Incentive (RHI) aimed at the non ETS-sector, which will be in place in 2016 subject to EU state aid clearance and further Government approval. It is intended that the renewable heat support will be based on the principle of providing an incentive payment rewarding users for each unit of renewable heat produced and used, based on a unit rate of payment (tariff) applied to metered renewable heat output. The tariff would be calculated to compensate for the additional capital cost for the renewable technology (which could include technologies other than biomass e.g. heat pumps) relative to fossil fuel heating. It is envisaged that the RHI will be funded by the Exchequer (DCENR, 2015). The consultation for the tariff setting of the RHI and development of the technology cost basis has only started in the second quarter of 2016.

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. These controlled the development and trend of the main fault structures of the Irish landmass. The presence of 42 warm springs across Ireland is largely associated with the occurrence of these regional fault structures and with the presence of Lower Carboniferous aged lithologies.

Temperatures of between 13°C and 24.7°C from the warm springs have been recorded as part of extensive research since the early 1980s and more recently as part of the IRETHERM project. 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 despite extensive research on the hydrochemistry, hydrogeological conditions and imaging of the associated fault structures using magnetotelluric surveys (Blake, 2016).

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).

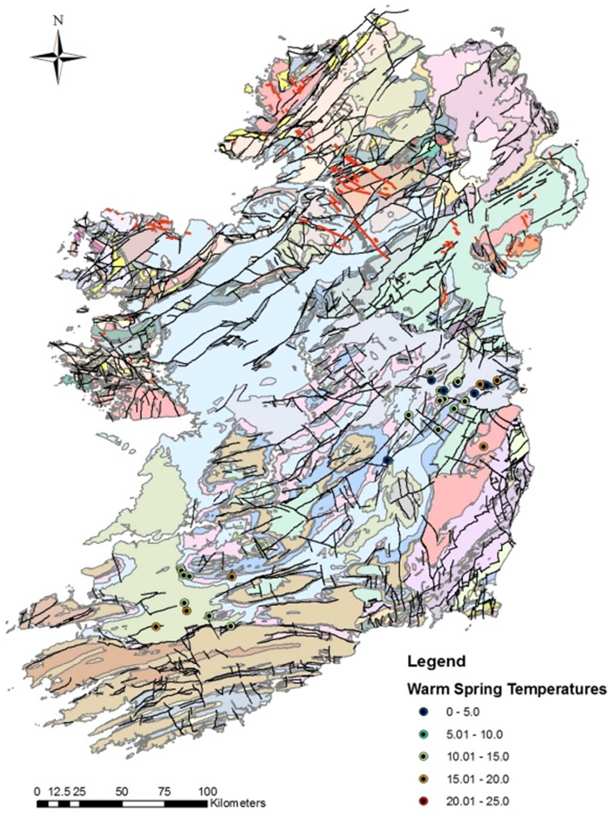

Figure 1: Bedrock Geological Map of Ireland (GSI, 2006) & location of warm springs.

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 3,000 m of Permo-Triassic sediments (McCann, 1991) where the highest measured temperatures at depth have been recorded.

Shallow geothermal energy resources are favoured 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.

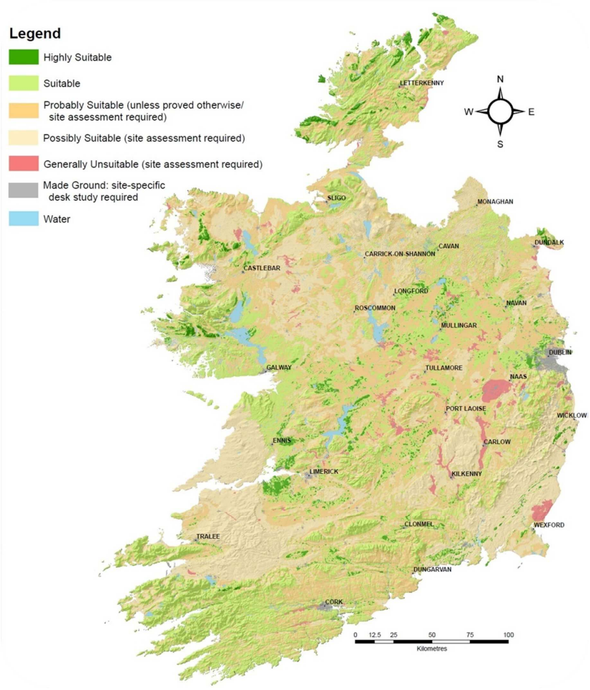

Figure 2: Vertical Closed Loop Collector Suitability Map (GSI, 2016).

. 3. SHALLOW GEOTHERMAL ENERGY UTILISATION:

The shallow geothermal energy utilisation in Ireland had a very high growth rate until 2009. The total estimated installed capacity for ground source heat pumps in 2015 is estimated at 191 MWth, with a thermal energy produced for heating of 251.64 GWh and 10.29 GWh for cooling (Table E).

The lack of a dedicated database for reporting the number and characteristics for the 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 data collected for the WGC2015 Country Update. Whilst, information on large scale commercial systems is available through the Geothermal Association of Ireland records, many installations remain poorly or not documented at all (see table 1).

Ground source heat pump installation figures from the Heat Pump Association for Ireland in 2015 show a total number of ground source installed units of 350 during the course, representing approximately an average 3% increase from the 2010 to 2015 period. (Cotter, *pers. comm.*).

The shallow geothermal energy market in Ireland remains dominated by the installations in the residential sector (c. 85%) with lower uptake in the commercial and industrial processes sector (14% and 4% respectively) with systems of intermediate installed capacity between 10kW and 40kW installed remain the most widespread.

Large scale, ground source systems are dominated by the installation of open loop collectors, with the majority of systems being installed ranging between 60kW to 200kW in size for heating and cooling applications during 2015.

The 2016 Annual Geothermal Association of Ireland conference included the Installation of the Year competition open to domestic and non-domestic installations. The GAI organises these competition to promote those examples of geothermal energy installations that were operating effectively and providing comfort to the end users. There were 6 installations deemed worthy of recognition and the benefits were measured. (Burgess 2016).

Kelly's showroom in Mouncharles, Co Donegal was the winner of the non-domestic category (figure 3). The system comprises a 38 kW geothermal system used for both heating and cooling. In heating mode, a heat-pump is used to provide warm water to under floor heating at 45^{o}C flow / 35^{o}C return water temperatures. In cooling mode, the Ground loop circuit takes heat from a heat exchanger to provide indirect cooling of the showrooms through a cooled floor.

Figure 3: Kelly's Showroom, Mouncharles, Co. Donegal (Burgess, 2016).

The 510m^2 showrooms uses approximately 66,000 kWh of heat each year, 129 kWh/m^2/annum. 14.4 tons of CO_2 emissions are saved from renewable energy of 63.2 kWh/m^2/annum. The energy offset from direct air-conditioning which is standard for car showrooms is a significant contributor to what is a low energy, low cost facility. Saving of €6,000 a year on heating costs alone result in a payback of 9 years. Recording of the ground loop brine temperatures indicate drops of 5^{o}C from overnight operation of heating. Summer temps of 16^{o}C provide ideal water for floor-slab cooling without condensation risk.

Another of the non-domestic entries included the Lisdoonan Community Residential Scheme (figure 4). Lisdoonan Home includes a 124 kW hybrid ground and air source system. The scheme comprises 14 two-bedroom bungalows and a communal dwelling for guests and residents. A district heating system is supplied from 4 heat pump plant rooms, each serving 4 houses. Each plant room holds a 14 kW ASHP and a 17 kW GSHP connected to horizontal closed loop pipework, 8 circuits of total length 120m, buried under 1.2m of topsoil. The 2 heat pumps operate in the most efficient mode (ground source or air source) depending on air and ground temperatures. Heating is distributed to the houses to feed an under floor heating manifold and a 150 litre DHW cylinder.

Figure 4: Lisdoonan Community Residential Scheme, Co. Monaghan (Burgess, 2016).

Average primary energy intensity of each house is 147 kWh/m^2/yr, achieving an equivalent operational BER of B3. The renewable energy provided by the hybrid heat pump system is approximately 111kWh/m^2/yr, 11 times the minimum threshold set by Part L of the Building Regulations.

65 tons of CO_2 emissions and heating costs of €22,000 are saved each year when compared to equivalent oil fired heating systems. A payback of 5 years is achieved.

The winner of the domestic category was a residential house in Blessignton Co. Wicklow (figure 5). The 8.6kW water to water system was installed in 2013. The system demonstrates an innovative application of heat-pump technologies to the extraction of heat from the residence's well water supply.

Figure 5: Residential House, Blessington, Co. Wicklow (Burgess, 2016).

Variable speed control of the well pump provides 9.6^{o}C water at pressure during the day to meet the domestic water requirements, whilst at night, the pump speed ramps down to maintain a low pressure, low flow supply to transfer waste cooling energy away from the heat-pump. Water is discharged at a temperature of 5.4^{o}C at a maximum rate of 0.4 litres per second. This system is supplied by a single well at a depth of 50m in granite bedrock.

The 210m^2 house dates from the 1980's and has been well insulated by the owner. Other technologies installed to meet the energy needs of the residence include a log stove being used as a secondary source of heat, 5m^2 solar thermal tubes provide most of the hot water needs during the summer and shoulder seasons. A PV panel array provides about 50% of the electricity needs of home.

The heat pump system displaced a 17kW oil boiler, and saves approximately €1,000 every year in energy cost and 2.8 tons of CO_2 emissions. Renewable energy contribution from the heat pump is 28 kWh/m^2/year. Payback on investment is expected to be achieved in 2019 (Burgess, 2016).

The Geothermal Association of Ireland also gave awards of merit to three other domestic installations in Streasmtown, Co. Westmeath, Tullow, Co. Carlow and Dunlewey, Co. Donegal.

4. DEEP GEOTHERMAL ENERGY DEPLOYMENT:

Deployment of deep geothermal energy resources in remains slow. Since the completion of an extensive geothermal exploration programme by the private sector comprising exploration wells in 2009, 2D seismic reflection and VSP surveys at Newcastle, South County Dublin, subsequent research has been undertaken by the IRETHERM programme using MT survey to determine the presence of permeable reservoir zones at depth. The results demonstrate that a conductive zone of interest between depths of up to 2,000m to 3,000m (figure 6) is present.

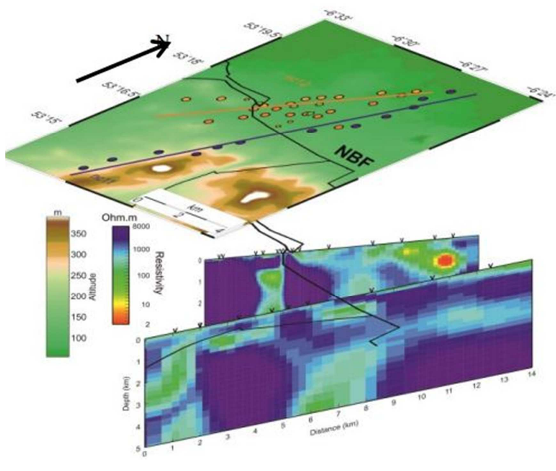

Figure 6: Resistivity Models from the Blackrock to Newcastle Fault Structure (Vozar, 2015).

Table 1: Non-domestic ground source heat pump installations in Ireland.

Locality	Ground or Water Temp.	Typical Heat Pump Rating or Capacity	Number of Units	Type	COP	Heating Equivalent Full Load	Energy Produced	Cooling Energy
	(°C)	(kW)				(hr/Year)	(GWh/yr)	(GWh/yr)
Domestic Installations Nationwide (Average Installed Capacity)	10	10.4	17380	H/W/V/O	3.5	1800	232.40	
Dolmen Centre, co. Donegal	10	45	1	H	3.5	1363	0.04	
Tralee Motor Tax Office, Co Kerry	10	120	1	H	3.5	1922	0.16	0.07
SHARE Hostel, Cork	15	120	1	W	3.5	1363	0.12	
UCC Glucksman Gallery, Cork	15	200	1	W	3.65	1922	0.28	0.11
Fexco HQ, Killorglin, Co Kerry	11	310	1	W	3.65	1922	0.43	0.17
Glenstal Abbey, Co Limerick	10	150	1	W	3.5	1363	0.15	
Musgrave HQ, Cork	10	160	1	V	3.65	1922	0.22	0.09
Killarney International Hotel, Co Kerry	11	60	1	W	3.5	1363	0.06	
Cork Co Council Environmental Labs	11	90	1	W	3.5	1363	0.09	
Cliffs of Moher Visitor Centre, Co. Clare	10	160	1	H	3.5	1363	0.16	
Killorglin Town Centre, Co Kerry	11	160	1	W	3.65	1922	0.22	0.09
Fermoy Leisure Centre, Co Cork	11	160	1	W	3.5	2725	0.31	
Tory Top Road Library, Cork	13	80	1	W	3.5	1363	0.08	
Coraville, Blackrock, Cork	13	36	1	W	3.5	1363	0.04	
Castleisland, Co Kerry	11	135	1	W	3.5	1363	0.13	
ESB Administration Offices, Cork	13	250	1	W	3.65	1922	0.35	0.14
Cork County Library, Cork	13	450	1	W	4	560	0.19	0.25
Swedish Ambassador's Residence, Dublin	12	21	1	V	3.5	1363	0.02	
Cowper Care, Kilternan, Dublin	8	100	1	V	3.5	1363	0.10	
Cowper Care, Rathmines, Dublin	8	66	1	V	3.5	1363	0.06	
Cowper Care, Dublin	11	86	1	V	3.5	1363	0.08	
Vista Health Care, Naas, Co Kildare	10	400	1	W	3.65	1922	0.56	0.23
UCC Western Gateway IT Building, Cork	15	1000	1	W	3.65	1922	1.40	0.56
Athlone City Centre Retail Complex, Westmeath	10	2786	1	W	3.65	1922	3.89	1.56
Lifetime Lab, Cork	12	70	1	W	3.5	1363	0.07	
Bagenalstown Swimming Pool, Co. Carlow	11	18	1	W	3.5	1363	0.02	
Croi Anu Creative Centre, Co. Kildare	10	8	1	H	3.5	1363	0.01	
Rathmore Community Childcare, Co. Kerry	11	12	1	V	3.5	1363	0.01	
Treacys Hotel Co. Wexford	11	450	1	V	3.65	1922	0.63	0.25
Fairy Bush Childcare Centre, Co Roscommon	11	23.5	1	V	3.5	1363	0.02	
Tinnypark Nursing Home, Co. Kilkenny	10	32	1	H	3.5	1363	0.03	
Goretti Quinn Creche, Co. Kildare	11	12	1	V	3.5	1363	0.01	
CloCeardlann na gCnoc, Co. Donegal	10	18.3	1	H	3.5	1363	0.02	
St John's National School, Co. Mayo	10	14.2	1	H	3.5	1363	0.01	
Dubin Dockland Development Authority	12	17.5	1	H	3.5	1363	0.02	
Dunmore House Hotel, Co. Cork	11	18	1	W	3.5	1363	0.02	
Comhaltas Cosanta Gaeltachts Chuil Aodha, Cork	11	16	1	V	3.5	1363	0.02	
David Cuddy, Rathbranagh, Co. Limerick	11	11.5	1	V	3.5	1363	0.01	
Skeaghanore Farm Fresh Duck, Co. Cork	11	12	1	V	3.5	1363	0.01	
Kanturk Sheltered Housing, Co. Cork	11	8.3	1	V	3.5	1363	0.01	
Comhlacht Forbartha an Tearmainn, Co. Donegal	11	33.6	1	V	3.5	1363	0.03	
Feohanagh Special Needs Housing, Co Limerick	11	17	1	V	3.5	1363	0.02	
CLS Rosmuc, Co. Galway	10	19.8	1	H	3.5	1363	0.02	
Vicarious Golf, Co. Wicklow	10	13	1	H	3.5	1363	0.01	
Inis Oirr Health Centre, Co. Galway	10	12	1	H	3.5	1363	0.01	
Children's and Adults Respite Centres, Co. Galway	11	21	1	V	3.5	1363	0.02	
Kilcurry Community Development, Co. Louth	11	17	1	V	3.5	1363	0.02	
Ardara Community Childcare, Co. Donegal	11	22.1	1	W	3.5	1363	0.02	
Seawright Swimming School Co. Cork	11	31	1	W	3.5	1363	0.03	
Cope Foundation, Bandon, Co. Cork	11	30	1	V	3.5	1363	0.03	
Parklands Apartment Development, Co. Wicklow	11	40	1	V	3.5	1363	0.04	
Ballyconnell Central National School, Co. Cavan	11	12	1	V	3.5	1363	0.01	
James B Joyce & Co, Co. Galway	11	18.3	1	V	3.5	1363	0.02	
Poor Clare Monastery, Co. Louth	11	18	1	W	3.5	1363	0.02	
Tralee Community Nursing Unit, Co. Kerry	11	100	1	V	3.5	1363	0.10	
Brook Lodge Hotel, Co Wicklow	10	134	1	H	3.5	1363	0.13	
Hudson Bay Hotel, Athlone, Co. Westmeath	11	132	1	W	3.5	1363	0.13	
Hotel Europe, Killarney, Co. Kerry	10	110	1	W	3.5	1363	0.11	
Rathass Housing Estate, Tralee, Co. Kerry	8	70	1	H	3.5	1363	0.07	
Whites Hotel, Wexford	10	21	1	H	3.5	1363	0.02	
Belinter Hotel, Navan, Co. Meath	10	306	1	H	3.65	1922	0.43	0.17
Bellview Woods Childcare, Killarney, Kerry	8	30	1	H	3.65	1922	0.04	0.02
D&G Electrinics Ltd, Castleisland, Co Kerry	8	21	1	H	3.5	1363	0.02	
Oilgate Nursing Home	8	100	1	V	3.5	1363	0.10	
Youghal Town Hall, Co Cork	8	21	1	V	3.5	1363	0.02	
Borris Nursing Home	14.65	74	1	W	3.8	3276	0.18	
Moyross Estate, Co. Limerick	9	140	1	V	4.1	1872	0.20	
Kilboy House, Tipperary	9	120	1	V	4.1	1872	0.17	
Vistakon Irleand, Limerick	12	890	1	W	5	4800	3.42	6.59
IKEA, Dublin	10	2000	1	V	3.5	1800	2.57	
Wonder Years Childcare Rossbrack, Manorcunningham Co. Donegal	8	43.6	1	H	4	1872	0.06	
Ballyroan Library, South Dublin	9.8	60	1	V	4.1	1872	0.08	
Cowper Care, Kilternan, Co Dublin	8	80	1	V	3.5	1872	0.11	
Mallow Swimming Pool, Co. Cork	15	100	1	W	3.5	4250	0.30	
Offaly Co. Council Offices, Tullamore, Co. Offaly	10	105	1	W	3	1872	0.13	
Kelly's Showroom, Mountcharles, Co Donegal	8.4	38	1	V			0.07	
Lisdoonan Community Residential Scheme, Co. Monaghan		124	4 GSHP & 4 ASHP	H & ASHP			0.32	
Offaly Co. Council Offices, Tullamore, Co. Offaly	10	105	1	W	3	1872	0.13	
TOTAL		193878	17457				251.64	10.29

5. LEGISLATIVE AND REGULATORY FRAMEWORK:

5.1 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. 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. Whilst the Minerals Development & Geothermal Energy Development Bill have not yet passed before government, the establishment of a new government in April of 2016 and the appointment of a new Minister committed to the development of renewables and in particular geothermal energy, provides renewed hope for the publication of the Bill in the near future.

The DCENR White Paper 'Ireland's Transition to a Low Carbon Energy Future 2015-2030' makes provisions for the establishment of a regulatory framework to facilitate the exploration for, and development of, geothermal energy resources, although the timing of consultation process for these regulations and their implementation is not yet known.

5.2 Shallow Geothermal Energy Resource Project

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). The project is led by the Groundwater Section of the Geological Survey of Ireland (GSI) which has been involved with geothermal resources since the 1960s.

A homeowners manual has been developed to assist with the choice of shallow geothermal energy systems installation, and to provide advice on procedures and methodologies with each phase of an installation as well as demonstrating the benefits of shallow geothermal energy systems compared to other renewable and fossil fuel fired heating systems. A draft technical guideline documents covering the design, installation and testing of ground source collectors has been prepared to cover the sub-surface aspects of shallow geothermal energy installations for horizontal collectors and vertical collectors and their construction. These comprise a technical guideline manual for system completion, promoting best practice methodologies and procedures for suitably trained professionals to install shallow geothermal energy systems in the context of the current environmental and building regulations.

A set of national collector suitability maps for closed loop vertical (figure 2) and open loop collectors have been developed. The maps have been generated using subsurface data currently available at GSI and in collaboration with other government agencies and research institutions that are compiling geothermal resource information. The maps are publicly available through an online viewer on the Geological Survey of Ireland website. The maps are intended as screening tools for decision maker and end user to highlight possible collector deployment options at a national scale.

6. BARRIERS TO DEPLOYMENT:

Current financial support measures specific to GSHPs are currently not available with the exception of only minor grant contributions towards system installation. The introduction of the carbon tax which places an extra cost on fossil fuels such as gas or oil has facilitated the reduction of payback periods to less than 10 years for systems that replace oil or LPG fuelled heating (Burgess 2011).

The main barrier to the development of deep geothermal energy resources in Ireland remain the lack of specific legislation allowing developers to obtain licenses for resource exploration and development. In addition, financial support for geothermal electricity generation has still not been considered by government through the REFIT scheme despite a target of 5 MWe installed capacity by 2020 being set as part of the NREAP for Ireland.

The lack of policy strategy to address the heat market and the potential contribution that district heating and renewable technologies including geothermal can contribute to addressing 47% of Ireland's energy demand are still missing.

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 and the national geothermal association. 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 economic benefits of 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 on the operational and economic aspects of operating plants. These would help to promote successful deployment strategies and target specific areas of Ireland's heat sector that could be best addressed with geothermal energy.

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 renewable energy resources including shallow and deep geothermal resources alike.

Dedicated training and certification for key contractors involved in the installation of heat pump systems is currently being undertaken through a 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, University College Dublin and Trinity 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. A new national certification training initiative combined with the second Geotrainet programme is being considered to promote a sustainable development of the shallow geothermal energy sector in Ireland.

7. ON GOING RESEARCH & PROJECTS:

The four and half year IRETHERM project focussed on the development of a strategic and holistic understanding of Ireland's geothermal energy potential has now concluded.

IRETHERM has developed integrated models for different type of geothermal targets through a comprehensive program of geophysical field surveys, geochemistry, hydrochemistry and thermal property studies to identify those geological settings/localities that present the greatest opportunity for harnessing deep geothermal energy. Promising results from some of the study areas have shown that potential for delivering deep geothermal heat in both Ireland and Northern Ireland is present but further research and investigation is required. The validation of some of the model and work undertaken as part of the project should be achieved through the collection of additional base data for each area, the completion of further heat flow measurement studies and the completion of a deep demonstration borehole.

The Irish Ground Thermal Properties Project (IGTP) is focussed on characterising the geothermal properties of Irish ground conditions and their suitability for deployment of closed loop collectors. This will be achieved by carrying out further site specific field tests on installed geothermal collectors where these are available. IGTP has obtained new data in different Irish ground conditions to facilitate design and sizing of geothermal collectors by installers and professionals through a public database.

The database comprises new thermal conductivity data from different Irish bedrock formations at a scale down to 1:100,000 for key lithologies in Ireland.

The thermal conductivity data from Irish rock formations is obtained through both laboratory and Thermal Response Tests.

The compiled data has been used to develop ground loop sizing tables based on Irish conditions for use in small scale closed loop collector installations. The project helps to facilitate the understanding of the potential of shallow geothermal resources in a given areas and inform engineers of ground condition considerations at the design stage.

The data from the project is publicly available and published through a website for dissemination to present project results through an interactive map and sizing tables (Pasquali, 2016).

The "CHeap and Efficient APplication of reliable Ground Source Heat exchangers and PumpS" CHEAP-GSHPs project kicked off in May 2015. (Cheap- GSHPs) project is funded by Horizon 2020, call LCE- 03-2014, under the technology-specific challenges in demonstrating of renewable electricity and heating/cooling technologies.

This new project is adopting a practical demonstration approach to new technologies in ground source heat exchangers (GSHE). The project is focussed on the development of more efficient and safe shallow geothermal systems and the reduction of the installation costs. An existing, innovative vertical borehole installation technology of coaxial steel

GSHE will be improved and a helix type GSHE with a new, innovative installation methodology will be developed. Decision support tools will also be developed to identify the best GSHE system to adopt based on climatic conditions and the building energy requirements. There will be a number of demonstration sites where the new technology will be tested. One of those sites will be in Ireland.

The involvement of Irish companies in this geothermal energy research maintains a momentum for geothermal energy exploitation in Ireland by providing regular interaction with local authority and government decision makers and making them aware of developments in Europe and demonstrating Ireland's potential geothermal energy resources contribution to the energy mix (O'Neill, 2015).

The Geological Survey of Ireland has funded three geothermal energy projects as part of the Geoscience 2015 research funding. The Irish Soils Thermal properties project is developing a database of thermal properties of soils and sub soils based on existing classifications to facilitate in the charaterisation and design of horizontal collectors. Two deep geothermal projects are using the recently acquired Tellus midlands airborne magnetic and EM data to assess the potential for identifying deep geothermal targets. The DeepGeo project is using an integrated interpretation and modelling of Tellus aeromagnetic, gravity, radiometric and multispectral analysis of satellite imagery datasets for exploration and identification of deep geothermal target areas in the midland valley terrane.

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Tables A-G

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

	Geothermal Power Plants		Total Electric Power in the country		Share of geothermal in total electric power generation	
	Capacity (MW_e)	Production (GWh_e/yr)	Capacity (MW_e)	Production (GWh_e/yr)	Capacity (%)	Production (%)
In operation end of 2015 *	N/A	N/A	N/A	N/A	N/A	N/A
Under construction end of 2015	N/A	N/A	N/A	N/A	N/A	N/A
Total projected by 2018	N/A	N/A	N/A	N/A	N/A	N/A
Total expected by 2020	N/A	N/A	N/A	N/A	N/A	N/A
In case information on geothermal licenses is available in your country, please specify here the number of licenses in force in 2015 (indicate exploration/exploitation, if applicable):						

* If 2014 numbers need to be used, please identify such numbers using an asterisk

Table B: Existing geothermal power plants, individual sites

Locality	Plant Name	Year commis-sioned	No of units **	Status	Type	Total capacity installed (MW_e)	Total capacity running (MW_e)	2015 pro-duction * (GWh_e/y)
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
total								

Key for status:		Key for type:			
O	Operating	D	Dry Steam	B-ORC	Binary (ORC)
N	Not operating (temporarily)	1F	Single Flash	B-Kal	Binary (Kalina)
R	Retired	2F	Double Flash	O	Other

* If 2014 numbers need to be used, please identify such numbers using an asterisk

** In case the plant applies re-injection, please indicate with (RI) in this column after number of power generation units

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

	Geothermal DH plants		Geothermal heat in agriculture and industry		Geothermal heat for individual buildings		Geothermal heat in balneology and other **	
	Capacity (MW_{th})	Production (GWh_{th}/yr)	Capacity (MW_{th})	Production (GWh_{th}/yr)	Capacity (MW_{th})	Production (GWh_{th}/yr)	Capacity (MW_{th})	Production (GWh_{th}/yr)
In operation end of 2015 *	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Under constru-ction end 2015	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total projected by 2018	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total expected by 2020	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

* If 2014 numbers need to be used, please identify such numbers using an asterisk

** Note: spas and pool are difficult to estimate and are often over-estimated. For calculations of energy use in the pools, be sure to use the inflow and outflow temperature and not the spring or well temperature (unless it is the same as the inflow temperature) for calculating the energy parameters, as some pool need to have the geothermal water cooled before using it in the pools.

Table D1: Existing geothermal district heating (DH) plants, individual sites

Locality	Plant Name	Year commis-sioned	CHP **	Cooling ***	Geoth. capacity installed (MW_{th})	Total capacity installed (MW_{th})	2015 produc-tion * (GW_{th}/y)	Geoth. share in total prod. (%)
Moyross, Co. Limerick	Moyross Estate	2011			0.14	0.14	0.2	80
Lisdoonan, Co. Monaghan	Community Residential Scheme	2003			0.068	0.124	0.32	60
Tralee, Co. Kerry	Rathass Housing Estate				0.07	0.07	0.07	100
total								

* If 2014 numbers need to be used, please identify such numbers using an asterisk

** If the geothermal heat used in the DH plant is also used for power production (either in parallel or as a first step with DH using the residual heat in the brine/water), please mark with Y (for yes) or N (for no) in this column.

*** If cold for space cooling in buildings or process cooling is provided from geothermal heat (e.g. by absorption chillers), please mark with Y (for yes) or N (for no) in this column. In case the plant applies re-injection, please indicate with (RI) in this column after Y or N.

Table D2: Existing geothermal direct use other than DH, individual sites

Locality	Plant Name	Year commis-sioned	Cooling **	Geoth. capacity installed (MW_{th})	Total capacity installed (MW_{th})	2015 produc-tion * (GWh_{th}/y)	Geoth. share in total prod. (%)
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
total							

* If 2014 numbers need to be used, please identify such numbers using an asterisk

** If cold for space cooling in buildings or process cooling is provided from geothermal heat (e.g. by absorption chillers), please mark with Y (for yes) or N (for no) in this column. In case the plant applies re-injection, please indicate with (RI) in this column after Y or N.

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

	Geothermal Heat Pumps (GSHP), total			New (additional) GSHP in 2015 *		
	Number	Capacity (MW_{th})	Production (GWh_{th}/yr)	Number	Capacity (MW_{th})	Share in new constr. (%)
In operation end of 2015 *	17,195	191	252	350 est	14 est	3
Projected total by 2018	18,250	225	270			

* If 2014 numbers need to be used, please identify such numbers using an asterisk

Table F: Investment and Employment in geothermal energy

	in 2015 *		Expected in 2018	
	Expenditures ** (million €)	Personnel *** (number)	Expenditures ** (million €)	Personnel *** (number)
Geothermal electric power	N/A	N/A		
Geothermal direct uses	N/A	N/A	5	25
Shallow geothermal	3.5	150	5	250
total	**3.5**	**150**	**10**	**275**

* If 2014 numbers need to be used, please identify such numbers using an asterisk

** Expenditures in installation, operation and maintenance, decommissioning

*** Personnel, only direct jobs: Direct jobs – associated with core activities of the geothermal industry – include "jobs created in the manufacturing, delivery, construction, installation, project management and operation and maintenance of the different components of the technology, or power plant, under consideration". For instance, in the geothermal sector, employment created to manufacture or operate turbines is measured as direct jobs.

Table G: Incentives, Information, Education

	Geothermal el. power	Geothermal direct uses	Shallow geothermal
Financial Incentives – R&D	The SEAI RD&D scheme as well as Science Foundation Ireland have and will fund research in geothermal system resource assessments	The SEAI RD&D scheme as well as Science Foundation Ireland have and will fund research in geothermal system resource assessments	The SEAI RD&D scheme as well as Science Foundation Ireland have and will fund research in shallow geothermal resource assessments and technology deployment options
Financial Incentives – Investment	No	No	No – Better Energy Home €600 grant towards improved controls when a heat pump is installed
Financial Incentives – Operation/Production	No	No – A Renewable Heat Incentive scheme including geothermal is currently under consideration	No – A Renewable Heat Incentive scheme including geothermal is currently under consideration
Information activities – promotion for the public	No	National Association Annual conferences & SEAI training for local authority personnel	National Association Annual conferences & SEAI training for local authority personnel
Information activities – geological information		National Association Workshops and GSI dissemination events	National Association Workshops and GSI dissemination events
Education/Training – Academic	Undergraduate Courses on geothermal energy as an optional course in Engineering	Undergraduate Courses on geothermal energy as an optional course in Engineering	Undergraduate Courses on geothermal energy as an optional course in Engineering
Education/Training – Vocational	No	No	Trainign and Certification for HP installers only

Key for financial incentives:		
DIS Direct investment support	FIT Feed-in tariff	-A Add to FIT or FIP on case

LIL	Low-interest loans	FIP	Feed-in premium		the amount is determined by auctioning
RC	Risk coverage	REQ	Renewable Energy Quota	O	Other (please explain)