Developments in Geothermal Utilization in the Irish Republic

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ABSTRACT

Geothermal energy exploitation in Ireland has expanded rapidly over the last few years, despite low geothermal gradients (<25°C/km) and limited geothermal resources. Emphasis is on exploitation of low temperature resources for space heating, employing heat pump technology, but a major new development is the first deep drilling project to source warmer water at depth for district heating projects, with a trial well drilled to over 1.3 km in the western suburbs of Dublin.

There has been a huge increase in the number of heat pump units installed in Ireland, since the last update in 2004, which now stands at approximately 9500 units. Take up has been mainly in the domestic market, with most heat pumps approximately 15 kW in size, but the number of larger scale installations ranging from about 100-450 kW servicing public buildings and institutional/commercial premises is increasing rapidly, and a few even larger developments have been recently installed or are in progress. Recently completed, a 3 MW open loop system at the Athlone City Centre Retail Complex is the largest individual geothermal space heating project in the country. Most domestic systems employ horizontal closed loop collectors, with the more expensive vertical closed loop collector systems mainly employed in urban areas where space is at a premium. Open loop collectors are less popular in the domestic market but preferred for larger systems, particularly in areas underlain by shallow gravel and karst aquifers, and enhanced in urban situations by slightly magnified groundwater temperatures due to the 'heat island' effect. A few projects have also employed open loop systems exploiting surface water sources such as ponds and reservoirs, where these exist. Current total geothermal energy usage in the form of heat pump capacity is estimated at 164 MW.

The rapid take up of heat pumps in the domestic market has largely resulted from the introduction from 2006 of various government grant schemes for renewables including GHP's to provide incentives to individual householders and developers to incorporate geothermal and other renewable energy systems into new or existing buildings. Another important recent government initiative has been a wide ranging consultation process with geothermal stakeholders as the initial step in bringing in regulatory controls to guide the development of geothermal energy in Ireland, and Ireland is also involved in the GTR-H project to standardize geothermal regulations throughout the EU. A further significant development is the initiation by Irish higher level institutions of new undergraduate and graduate degree programs in energy engineering, with geothermal energy and heat pump technology part of the curricula.

1. INTRODUCTION

Concerns about greenhouse gas emissions and its relationship to climate change, together with uncertainties regarding peak oil and security of supply of oil and gas has led the Irish Government in the last 4-5 years to heavily promote the development of renewable energy. Even so, in 2007, 96% of all energy used in Ireland (population ~ 4.5 million) was generated by fossil fuels (Howley et al, 2008a), with only a little over 1.5% generated by renewable, mainly wind and solid biomass. About 33% of the total primary energy supply in Ireland in 2007 was used for thermal purposes (space, process and water heating and also cooking), with a renewable energy contribution of 3.5%. Targets for future renewable energy contributions for 2010 and 2020 are 5% and 12% respectively (Howley et al, 2008a; 2008b). Of thermal energy usage, the residential sector accounts for the largest share (42%). and use of renewable energy for home heating represented 13% of the total renewable energy thermal energy usage in Ireland in 2007, although geothermal energy contributed only 0.3% of this amount (Howley et al, 2008a; 2008b). Furthermore, from 1990 to 2007, total CO_2 emissions increased by 51% (Howley et al, 2008a), significantly exceeding Irelands Kyoto Protocol commitment of maintaining CO_2 emissions to 13% above 1990 levels by 2012 (Fig. 1).

Nevertheless, geothermal energy exploitation in Ireland has expanded rapidly over the last few years, despite low geothermal gradients and limited geothermal resources apart from 42 warm springs concentrated in two groups, in the SW and E of the country. Emphasis is on exploitation of low temperature resources for space heating, employing heat pump technology, but a major new development is the first deep drilling project to source warmer water at depth for district heating projects, with a trial well drilled to over 1.3 km in the western suburbs of Dublin.

The main agencies involved in the development of geothermal energy in Ireland are the Geothermal Association of Ireland (GAI), Sustainable Energy Ireland (SEI), the Geological Survey of Ireland (GSI), 15 energy agencies throughout Ireland, (O'Brien 2001), the Irish Association of Hydrogeologists (IAH), and some private companies. The GAI is a voluntary organization consisting of professionals from both the commercial and academic sectors with various backgrounds including geologists and hydrogeologists, service and mechanical engineers, heat pump suppliers and installers, well-drillers and lawyers. Its aim is to promote awareness and utilization of geothermal energy in Ireland. Of the 15 energy agencies, the most active are in the Cork area. SEI is an Irish government organization set up in 2002 with a mission to promote and assist the development of sustainable energy in the Irish Republic.

2. GEOLOGY BACKGROUND

Ireland generally consists of a mountainous rim composed of Precambrian to Lower Palaeozoic crystalline rocks surrounding a lowland interior largely underlain by U. Devonian to L. Carboniferous sandstone, shale and limestone (Figs. 2 & 3). Late Palaeozoic, Mesozoic and Tertiary rocks are absent, apart from in the NE corner of the island, where they are preserved beneath the basalt plateau of the 50-60 Ma Tertiary North Atlantic Igneous Province associated with the opening of the North Atlantic. However, there is evidence that they were also deposited over much of the rest of the island, but were stripped away by the intense erosion and peneplanation which accompanied the opening of the North Atlantic.

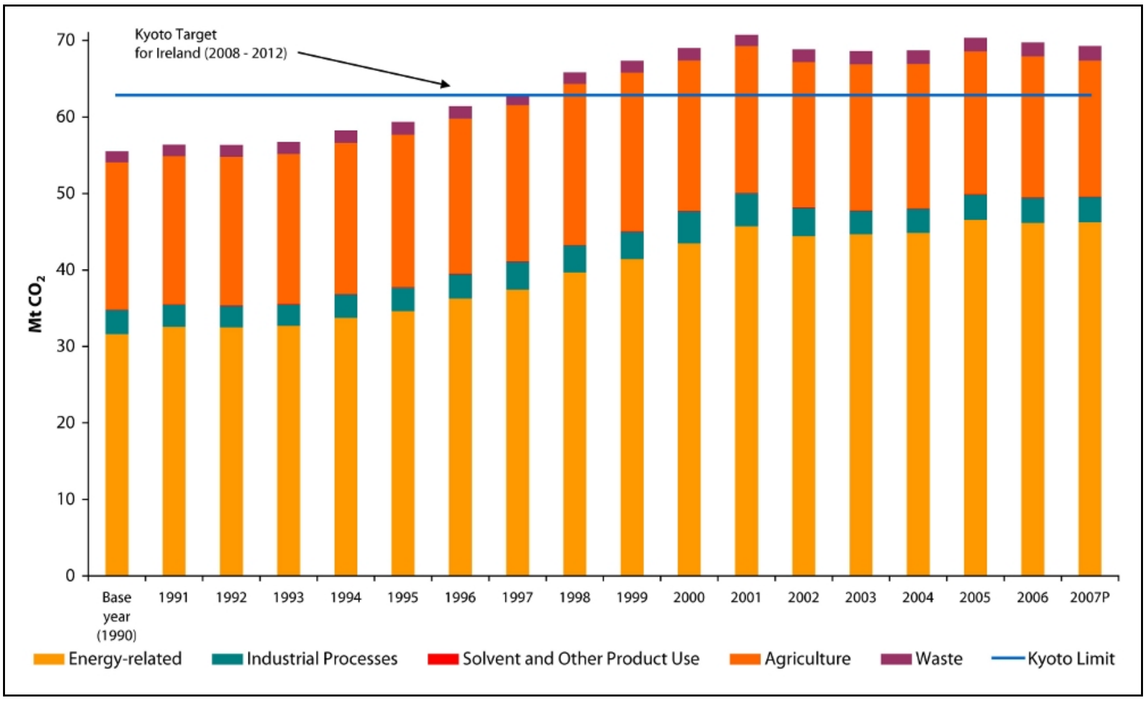

Fig. 1: Trend in Annual GHG Emissions for the Period 1990 to 2007 (Howley et al, 2008)

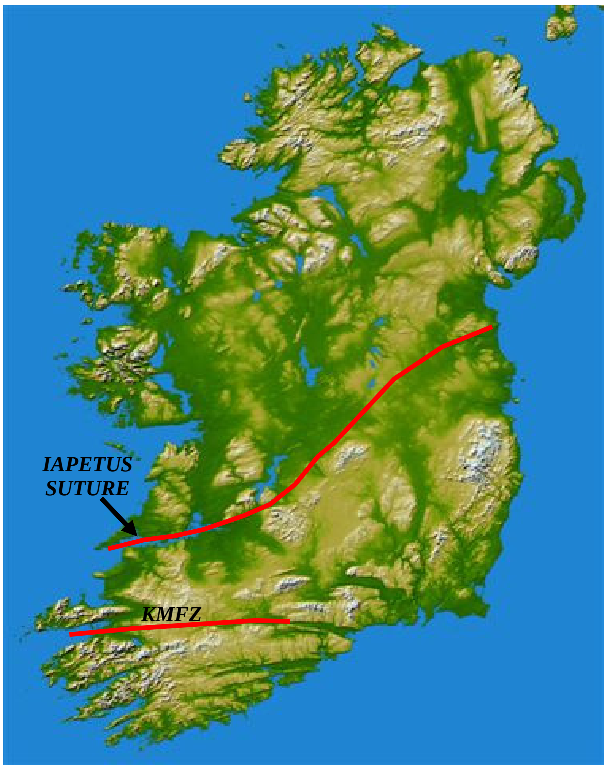

Fig. 2: Landsat Topographic Map of Ireland showing tectonic boundaries referred to in the text. KMFZ - Killarney-Mallow Fault Zone

Fig. 3: Geological Map of Ireland. L. Carboniferous limestone (pale blue) underlies much of the interior of the country

U. Palaeozoic bedrock, whilst underlying much of the interior of Ireland, is generally buried beneath a cover of Pleistocene glacial till and Holocene peat deposits, and is rarely exposed. Widely developed L Carboniferous limestone (Fig. 3) is extensively karstified, but overburden deposits are relatively thick and surface expression of karst is generally absent. Thus, most of Ireland's limestone bedrock consists of buried karst.

Ireland lies within the Caledonian orogenic belt (Fig. 4), which affected all Precambrian and L. Palaeozoic units. The Iapetus Suture (Fig. 2), marking the collision zone of Laurentia and Avalonia, runs diagonally across Ireland from the Shannon estuary to Clogher Head, 50 km to the north of Dublin. All of the warm springs in the Irish Republic lie to the south of this tectonic line.

The late Carboniferous Variscan (Hercynian) Orogeny affected the very south-west of Ireland, which represents the westernmost extension of the external Rheno-Hercynian Zone of the Variscan Orogenic Belt. Its northern boundary, the Variscan Front, is the Killarney-Mallow Fault Zone (KMFZ), which runs E-W, midway between the south coast of Ireland and the Shannon estuary (Fig. 2). The southwestern group of warm springs are all situated just to the north of this tectonic boundary.

3. GEOTHERMAL RESOURCES AND POTENTIAL

Due to its within-plate setting distant from plate boundaries, and an absence of recent volcanism or tectonism, geothermal gradients in the Irish Republic are low (<25°C/km) (Goodman et al, 2004). Thus Ireland is unlikely to possess any high temperature geothermal resources. Typical groundwater temperatures in Ireland vary from approximately 10-12°C, whilst soil temperatures are between 8-12°C Aldwell (1997). These temperatures reflect the balance between solar and geothermal recharge, and radiation from the ground surface as quantified by Aldwell & Burdon (1986), and remain relatively constant throughout the year due to Ireland's temperate maritime climate. Modern heat pump technology allows heat to be extracted from soil and groundwater at these low but consistent temperatures, in Ireland mainly for space heating and cooling uses.

Springs, seepages and spring wells are ubiquitous in Ireland, particularly in Dinantian limestone bedrock that underlies much of the Irish midlands. Potentially exploitable geothermal resources occur where relatively warm groundwater (>13^{o}C) is able to rise rapidly to the surface (Aldwell, 1996), discharging as low enthalpy geothermal springs. 42 of these warm springs, mainly located in limestone, and ranging in temperature from 13-24.7°C have been recorded (Aldwell & Burdon, 1980; Burdon, 1983; Brück et al, 1986; Aldwell 1996; Goodman et al, 2004), and are concentrated in two groups in the east and southwest of the country (Fig. 5). One of the earliest recorded warm springs in Ireland occurs at Mallow in the southwest, where the spring at Lady's Well gave rise, in the 18th and 19th Centuries, to a spa resort. Apart from this spring, which has more recently been harnessed to heat the municipal swimming pool (O'Brien, 1987), little utilization of these warm water energy resources has taken place, mainly because of the rural settings in which most occur, that in the past has limited potential options for their exploitation.

Geothermal gradients in the island of Ireland generally increase from SW to NE, from lows of approximately 10°C/km in the south to highs associated with the Tertiary igneous activity in the NE, where a maximum of 35°C/km has been measured (Goodman et al, 2004). Low yields of relatively hot water at 88°C were encountered in the early 1980's in a borehole to 2.8 km depth at Larne to the NE of Belfast, within the Permo-Triassic Sherwood Sandstone, an aquifer widespread in Britain, but only present in Ireland in the extreme NE preserved beneath the Tertiary Basalt plateau. This temperature represents a geothermal gradient of about 27.5°C/km.

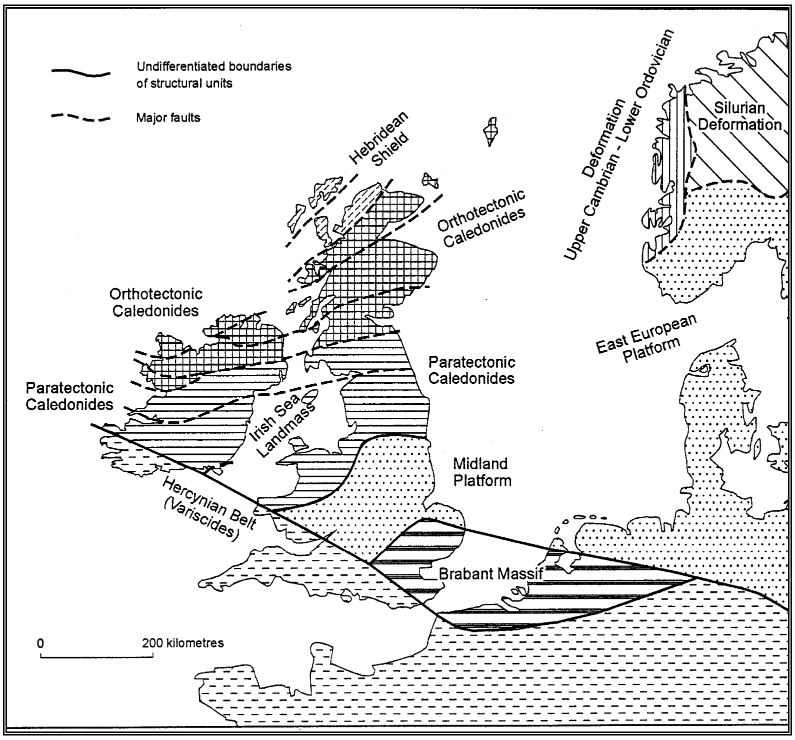

Fig. 4: Irelands Tectonic Setting.

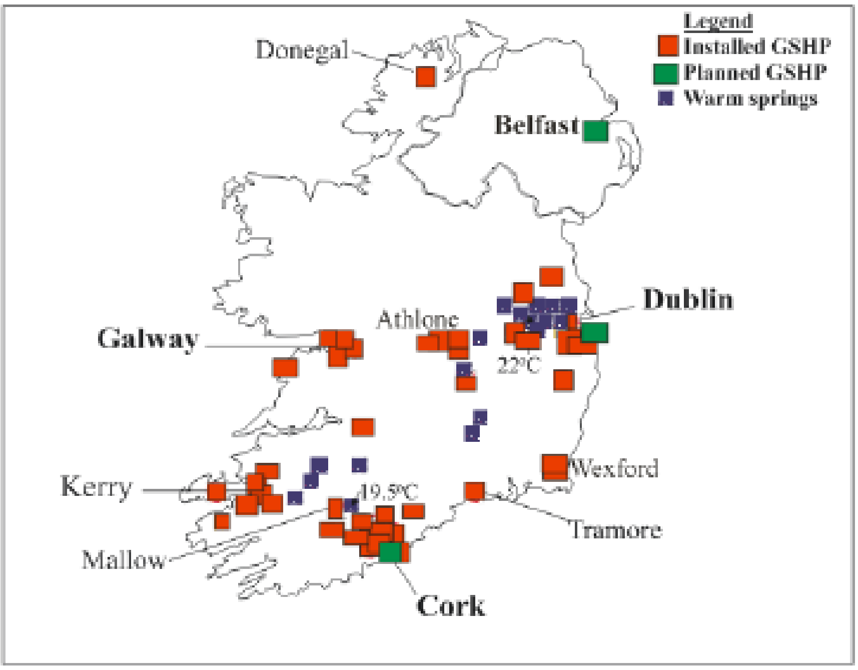

Fig. 5: Location of Warm Springs and Large Scale Installations in Ireland.

In the Irish Republic, conditions for generation of hot water at depth are not favorable, but the presence of 42 warm springs, indicates that aquifers do occur at depth, and that moderate geothermal resources, which could be exploitable, do exist. A borehole drilled to 1.4 km in the western suburbs of Dublin in 2008 encountered warm water at 46.2°C, representing a geothermal gradient of about 26.5°C/km. At the borehole location, a thick overlying layer of impermeable shales blankets and insulates the underlying aquifer.

Also, a well drilled for water supply purposes by Cork County Council in 2003 at Johnstown in the Glanworth area of North Cork in the southwest encountered, at a depth of 40m, warm groundwater at temperatures of 23-26°C. This, the warmest shallow groundwater as yet recorded in the Republic of Ireland, probably represents groundwater from a depth in excess of 1.5km, which has migrated rapidly up a fault conduit (Mooney et al, this volume). Finally, a well drilled on University College Cork campus within gravels close to the northern margin of the Lee Buried Valley (Allen et al, 1999) intersected limestone bedrock at 20m and encountered water with an anomalous temperature of 19-20°C. A caliper log of the borehole revealed a parallel temperature and conductivity increase downwards, indicating that the warm groundwater is not of anthropogenic origin and comes from the limestone bedrock, probably also representing groundwater from depth that has migrated up a fault conduit.

4. GEOTHERMAL UTILIZATION

Since Ireland has no high temperature geothermal resources, there is no electricity generation in the republic. Generally direct heat usage involves extraction of low enthalpy heat, which is employed with heat pumps mainly for space heating. As indicated above, none of Irelands warm springs are exploited apart from the Lady's Wells spring at Mallow, which with the aid of a heat pump is used to heat the municipal swimming pool (O'Brien, 1987), the first exploitation of geothermal energy in Ireland.

There has been a huge increase in the number of domestic heat pump units installed in Ireland, since the last update in 2004, and this now stands at approximately 9,500 units as of September 2009, with a further 300 installations in progress. This is an increase of about 8,000 installations in the last 5 years, brought about mainly due to the introduction by SEI of the Reheat and Greener Homes Grant Schemes in 2006, which aim to increase the use of sustainable energy technologies within both public and commercial buildings, and in domestic dwellings. The grants cover, amongst other space heating technologies, heat pumps using horizontal or vertical closed loop, well water open loop or air source collectors. Of the different GSHP collector systems, horizontal closed loop are the most popular (67.5%) followed by vertical closed loop (30%), and open loop (2.5%).

The popularity of horizontal closed loop systems is governed by the fact that Ireland has a high proportion of domestic dwellings with gardens, so space is available for horizontal collectors which are considerably cheaper to install than vertical collectors. In addition, horizontal heat collectors are very efficient due to Ireland's temperate maritime climate with its limited annual temperature range and abundant year round rainfall. Therefore there is little annual variation in soil temperature below depths of about 50 cm and soil moisture contents are typically high, so conditions are ideal for shallow horizontal collectors.

Vertical closed loop collectors are more common in cities where space is at a premium, but are considerably more expensive to install, although they attract larger grants from SEI. A small number of domestic units operate with open loop collectors, where a suitable aquifer underlies the site. A significant proportion of domestic heat pumps (>1500) employ an air source, which may reflect a lack of understanding of the principles of heat pumps by the homeowner or misleading advice by the installer.

Commercial heat pump installations are far less common than domestic units, but show a significant increase since the previous update report (O'Connell et al, 2005). Approximately 30 commercial GSHP projects have benefited from the SEI Reheat grant scheme, and another 10 public projects have been grant aided by the SEI Public Sector Program.

Most commercial heat pump projects have relatively small capacities being less than 50 kW, but quite a few are larger than 100 kW ranging up to a 3 MW system commissioned recently at Athlone city centre retail complex. In general, Cork leads the way in GHP development, with Cork City Council and UCC taking advantage of the combination of a shallow gravel aquifer underlying Cork (Allen & Milenic, 2003), and the 'heat island' effect (Allen et al, 2003). A significant number of public buildings in Cork are now heated by GHP systems. The flagship projects are a 200 kW open loop system heating and cooling an art gallery on UCC campus (Gondwe et al, this volume), a 1 MW open loop system heating a new IT complex at UCC, an 88 kW open loop system at the UCC Environmental Research Institute (ERI), and a 450 kW open loop system at the new Cork County Library. In addition, the Electricity Supply Board, the semi state body which until recently has had a monopoly on Irish electricity supply has also installed a 250 kW open loop GHP system at its Cork headquarters. Fig. 5 shows the locations of some of the larger commercial GSHP installations

Few retrofit systems have been undertaken in Ireland, but of note are three installations. The first is the conversion of the Swedish Ambassadors residence in Dublin, where a 21 kW heat pump with vertical closed loop heat collectors installed in 3 x 130 m boreholes, is delivering 60°C water to existing radiators and some additional under-floor heating areas. In Cork, the Lifetime Lab is a 19^{th} century waterworks pump house complex, which has been converted to an educational and conference centre with a 70 kW open loop system operating with under-floor heating. The Fermoy Leisure Centre in County Cork is a swimming pool complex, which has been converted to geothermal via a 160 kw open loop heat pump system.

The current estimate by SEI of heat pump capacity in the Irish Republic is 164 MW as of the end of 2008. The majority of systems are in domestic dwellings, with a total capacity of 148 MW, whilst installations in public buildings and commercial premises account for 16 MW total capacity. The average installed load capacity is about 15 kW for domestic dwellings, and of the order of 55 kW for public and commercial buildings

A major development in Ireland is the first deep geothermal exploration project since the Larne borehole in 1982. This borehole mentioned earlier was sunk in 2008 into the Dublin Basin at Newcastle in the western suburbs of Dublin in search of geothermal water for a potential commercial district heating scheme. The borehole reached a depth of 1.337 km encountering groundwater with a temperature of 46.2°C. Although a porosity of 22% has been established for the host rock, no hydraulic conductivity has been determined. Owing to a slump in the construction industry, resulting from the economic downturn in Ireland, this project has progressed no further. University College Dublin (UCD) is also investigating the feasibility of drilling a deep borehole into the Dublin Basin on its Belfield campus in the SE of Dublin to generate a campus district heating scheme.

5. DISCUSSION

The capacity factor for Irish heat pump installations (Table 1) is low due to the mild climate and the design of the heat pump systems. Heating is only required for 8 months of the year and air conditioning is not required for the domestic sector. The average annual air temperature is 9°C. The average mean daily minimum temperature in winter is 2.5°C. Average annual ground temperatures are of the order of 10ºC. Heat pump installations are designed to operate on the cheaper night rate electricity during the winter and so the compressor would be switched on for 7 hours out of 24. Heat is delivered to the building by under floor heating and so discharged slowly throughout the day.

Air conditioning is generally achieved by direct cooling, which circulates fluid from the collector in coils or circuits installed in the building ceilings or floors. Reversible heat pumps are typically used, but in many commercial building applications conventional water cooled chillers connected to heated and cooled buffer vessels are common. As the ground or water temperature is sufficiently low during the summer direct cooling can be used to provide some cooling. The installed capacity estimate is based on the projected cooling load for the building. Requirements for air conditioning or summer cooling are generally less than half the winter heating load.

A number of swimming pool projects (Table 2) use heat pumps not direct heating. The Fermoy pool, commissioned in 2008, is the largest. The capacity factor, estimated at 0.311, is larger than the other space heating installations because the heating demands of the swimming pool and showers are much greater.

The number of professional people involved in geothermal in Ireland is shown in Table 3. The majority work in GSHP and the rapid growth in the GSHP industry can be seen through the dramatic increase in installers and consultants working in the industry. Almost 350 installers, mainly plumbers, are registered with SEI, but the majorities are not solely employed in the GSHP sector, and most probably have limited specialized training in heat pump systems.

Similarly, a significantly increased number of HVAC consulting companies have become involved in the design of geothermal systems, but their portfolios would not be restricted to geothermal, so in Table 7 an estimate of full-time equivalent persons has been entered. There are however a limited number of small dedicated geothermal consultants.

There are no dedicated persons working on geothermal or GSHP in state funded organizations such as SEI and the local Energy Agencies, but over 50% of enquiries received regarding renewable energy are about GSHP, and 23% of applications under the Greener Homes Scheme have been for heat pump grants. Again a nominal number of full-time equivalents are entered in Table 2.

In Universities and Institutes of Technology, postgraduate research has been conducted on GSHP collector efficiency (e.g. Lohan et al, 2006), on optimal configurations of GSHP collectors (Liddy, 2008) on general assessment of the technology (O'Connell, 2004), and on performance analysis of installed heat pump systems (Gondwe et al, this volume). Geological aspects of geothermal such as delineation of fault conduits controlling ascent of geothermal waters (Mooney et al, this volume), and the impacts of GSHP groundwater withdrawals on saline/freshwater relations in estuarine environments and on subsidence in clays in interlayered clay/gravel sequences are also being investigated. Estimates of investment in geothermal is indicated in Table 4.

Table 1: GSHP Heat Pump Installations

Locality	Ground or water temp. (°C)[1]	Typical Heat Pump Thermal Rating Htg / Clg Capacity (kW)	Number of Systems	Type[2]	COP[3]	Htg & Clg Equivalent Full Load Hr/Year[4]	Thermal Energy Used (TJ/yr)	Cooling Energy Used (TJ/yr)	Electrical Energy Input (TJ/yr)
Domestic Installations Nationwide	10	15	9500	H	3.5	1363	699.0480	0.0000	199.7280
Dolmen Centre, co. Donegal	10	45	1	H	3.5	1363	0.2208	0.0000	0.0631
Tralee Motor Tax Office, Co Kerry	10	120	1	H	3.5	1922	0.8304	0.2418	0.2373
SHARE Hostel, Cork	15	120	1	W	3.5	1363	0.5887	0.0000	0.1682
UCC Glucksman Gallery, Cork	15	200	1	W	3.65	1922	1.3841	0.4030	0.3797
Fexco HQ, Killorglin, Co Kerry	11	310	1	W	3.65	1922	2.1453	0.6246	0.5885
Glenstal Abbey, Co Limerick	10	150	1	W	3.5	1363	0.7358	0.0000	0.2102
Musgrave HQ, Cork	10	160	1	V	3.65	1922	1.1073	0.3224	0.3037
Killarney International Hotel, Co Kerry	11	60	1	W	3.5	1363	0.2943	0.0000	0.0841
Cork Co Council Environmental Labs	11	90	1	W	3.5	1363	0.4415	0.0000	0.1261
Cliffs of Moher Visitor Centre, Co. Clare	10	120	1	H	3.5	1363	0.5887	0.0000	0.1682
Killorglin Town Centre, Co Kerry	11	160	1	W	3.65	1922	1.1073	0.3224	0.3037
Fermoy Leisure Centre, Co Cork	11	160	1	W	3.5	2725	1.5698	0.0000	0.4485
Tory Top Road Library, Cork	13	80	1	W	3.5	1363	0.3924	0.0000	0.1121
Coraville, Blackrock, Cork	13	36	1	W	3.5	1363	0.1766	0.0000	0.0505
Castleisland, Co Kerry	11	135	1	W	3.5	1363	0.6623	0.0000	0.1892
ESB Administration Offices, Cork	13	250	1	W	3.65	1922	1.7301	0.5037	0.4746
Cork County Library, Cork	13	450	1	W	4.00	560	0.9067	0.9067	0.2267
Swedish Ambassador's Residence, Dublin	12	21	1	V	3.5	1363	0.1030	0.0000	0.0294
Cowper Care, Kilternan, Dublin	8	100	1	V	3.5	1363	0.4906	0.0000	0.1402
Cowper Care, Rathmines, Dublin	8	66	1	V	3.5	1363	0.3238	0.0000	0.0925
Cowper Care, Dublin	11	86	1	V	3.5	1363	0.4219	0.0000	0.1205
Vista Health Care, Naas, Co Kildare	10	400	1	W	3.65	1922	2.7682	0.8059	0.7593
UCC Western Gateway IT Building, Cork	15	1000	1	W	3.65	1922	6.9204	2.0148	1.8983
Athlone City Centre Retail Complex, Westmeath	10	2786	1	W	3.65	1922	19.2802	5.6132	5.2887
Lifetime Lab, Cork	12	70	1	W	3.5	1363	0.3434	0.0000	0.0981
Bagenalstown Swimming Pool, Co. Carlow	11	18	1	W	3.5	1363	0.0883	0.0000	0.0252
Croi Anu Creative Centre, Co. Kildare	10	8	1	H	3.5	1363	0.0392	0.0000	0.0112
Rathmore Community Childcare, Co. Kerry	11	12	1	V	3.5	1363	0.0589	0.0000	0.0168
Treacys Hotel Co. Wexford	11	450	1	V	3.65	1922	3.1142	0.9067	0.8542
Fairy Bush Childcare Centre, Co Roscommon	11	23.5	1	V	3.5	1363	0.1153	0.0000	0.0329
Tinnypark Nursing Home, Co. Kilkenny	10	32	1	H	3.5	1363	0.1570	0.0000	0.0449
Goretti Quinn Creche, Co. Kildare	11	12	1	V	3.5	1363	0.0589	0.0000	0.0168
CloCeardlann na gCnoc, Co. Donegal	10	18.3	1	H	3.5	1363	0.0898	0.0000	0.0256
St John's National School, Co. Mayo	10	14.2	1	H	3.5	1363	0.0697	0.0000	0.0199
Dubin Dockland Development Authority	12	17.5	1	H	3.5	1363	0.0858	0.0000	0.0245
Dunmore House Hotel, Co. Cork	11	18	1	W	3.5	1363	0.0883	0.0000	0.0252
Comhaltas Cosanta Gaeltachts Chuil Aodha, Cork	11	16	1	V	3.5	1363	0.0785	0.0000	0.0224
David Cuddy, Rathbranagh, Co. Limerick	11	11.5	1	V	3.5	1363	0.0564	0.0000	0.0161
Skeaghanore Farm Fresh Duck, Co. Cork	11	12	1	V	3.5	1363	0.0589	0.0000	0.0168
Kanturk Sheltered Housing, Co. Cork	11	8.3	1	V	3.5	1363	0.0407	0.0000	0.0116
Comhlacht Forbartha an Tearmainn, Co. Donegal	11	33.6	1	V	3.5	1363	0.1648	0.0000	0.0471
Feohanagh Special Needs Housing, Co Limerick	11	17	1	V	3.5	1363	0.0834	0.0000	0.0238
CLS Rosmuc, Co. Galway	10	19.8	1	H	3.5	1363	0.0971	0.0000	0.0278
Vicarious Golf, Co. Wicklow	10	13	1	H	3.5	1363	0.0638	0.0000	0.0182
Inis Oirr Health Centre, Co. Galway	10	12	1	H	3.5	1363	0.0589	0.0000	0.0168
Children's and Adults Respite Centres, Co. Galway	11	21	1	V	3.5	1363	0.1030	0.0000	0.0294
Kilcurry Community Development, Co. Louth	11	17	1	V	3.5	1363	0.0834	0.0000	0.0238
Ardara Community Childcare, Co. Donegal	11	22.1	1	W	3.5	1363	0.1084	0.0000	0.0310
Seawright Swimming School Co. Cork	11	31	1	W	3.5	1363	0.1521	0.0000	0.0434
Cope Foundation, Bandon, Co. Cork	11	30	1	V	3.5	1363	0.1472	0.0000	0.0420
Parklands Apartment Development, Co. Wicklow	11	40	1	V	3.5	1363	0.1962	0.0000	0.0561
Ballyconnell Central National School, Co. Cavan	11	12	1	V	3.5	1363	0.0589	0.0000	0.0168
James B Joyce & Co, Co. Galway	11	18.3	1	V	3.5	1363	0.0898	0.0000	0.0256
Poor Clare Monastery, Co. Louth	11	18	1	W	3.5	1363	0.0883	0.0000	0.0252
Tralee Community Nursing Unit, Co. Kerry	11	100	1	V	3.5	1363	0.4906	0.0000	0.1402
Brook Lodge Hotel, Co Wicklow	10	134	1	H	3.5	1363	0.6574	0.0000	0.1878
Hudson Bay Hotel, Athlone, Co. Westmeath	11	132	1	W	3.5	1363	0.6475	0.0000	0.1850
Hotel Europe, Killarney, Co. Kerry	10	110	1	W	3.5	1363	0.5396	0.0000	0.1542
Rathass Housing Estate, Tralee, Co. Kerry	8	70	1	H	3.5	1363	0.3434	0.0000	0.0981
Whites Hotel, Wexford	10	21	1	H	3.5	1363	0.1030	0.0000	0.0294
Belinter Hotel, Navan, Co. Meath	10	306	1	H	3.65	1922	2.1176	0.6165	0.5809
Bellview Woods Childcare, Killarney, Kerry	8	30	1	H	3.65	1922	0.2076	0.0604	0.0569
D&G Electrinics Ltd, Castleisland, Co Kerry	8	21	1	H	3.5	1363	0.1030	0.0000	0.0294
Oilgate Nursing Home	8	100	1	V	3.5	1363	0.4906	0.0000	0.1402
Youghal Town Hall, Co Cork	8	21	1	V	3.5	1363	0.1030	0.0000	0.0294
		151696.1					**756.0798**	**13.3420**	**215.5126**

Table 2: Summary Table of Direct Heat Use

Use	Installed Capacity[1)] (MWt)	Annual Energy Use[2)] (TJ/yr = 10^{12} J/yr)	Capacity Factor[3)]
Individual Space Heating[4)]	None		
District Heating [4)]	None		
Air Conditioning (Cooling)	6.622	13.342	0.064
Greenhouse Heating	None		
Fish Farming	None		
Animal Farming	None		
Agricultural Drying[5)]	None		
Industrial Process Heat[6)]	None		
Snow Melting	None		
Bathing and Swimming[7)]	1.452	7.9078	0.173
Other Uses (specify)	None		
Subtotal	**8.074**	**21.2498**	**0.083**
Geothermal Heat Pumps (Heating)	151.696	744.1605	0.156
TOTAL	**159.770**	**765.4103**	**0.152**

Table 3: Allocation of Professional Personnel

Year	Professional Person-Years of Effort					
	(1)	(2)	(3)	(4)	(5)	(6)
2005	10 (equiv.)	None	None	None	None	10 (equiv)
2006	15 (equiv.)	None	None	None	None	20 (equiv)
2007	15 (equiv.)	None	None	None	None	30 (equiv)
2008	15 (equiv.)	None	None	None	None	40 (equiv)
2009	15 (eqiuiv)	None	None	None	None	50 (equiv)
Total	70(equiv)	None	None	None	None	150 (equiv)

Table 4: Total Investments in Geothermal

Period	Research & Development Incl. Surface Explor. & Exploration Drilling	Field Development Including Production Drilling & Surface Equipment	Utilization		Funding Type	
			Direct	Electrical	Private	Public
	Million US$	Million US$	Million US$	Million US$	%	%
1995-1999	0.2		0.5		70	30
2000-2004	1		16		80	20
2005-2009	7.5		225		90	10

The huge increase in the number of GSHP systems installed in Ireland over the last 4 years, which has raised the total heat pump capacity from about 40 to 164 MW has stemmed from public concern for climate change and reduction in CO_2 emissions, and also the desire by businesses and individual householders to reduce heating costs. In addition, the grant aid introduced by SEI on behalf of the Irish Government for both domestic, commercial and public sector projects, through the Greener Homes, Reheat and Public Sector programs has also had a major effect in stimulating this growth. However, failure of heat pump systems, or systems that fail to perform up to expectations are problems which threaten the development of the whole sector. A number of reasons for these failures are:

- installation by insufficiently qualified installers
- poor and misleading advice on the most suitable heat collection system
- failure to size the collector system properly
- unsatisfactory commissioning of the heat pump system
- failure to install a Building Management System (BMS) or installation of a BMS without a data archival feature
- failure to instruct the client in operation and adjustment of the BMS and heat pump system
- absence of post installation monitoring and back-up by installer

These and a lack of confidence in heat pumps by many HVAC engineers, have hindered the growth of heat pumps in the commercial sector of the Irish market.

On the brighter side, over the last few years in Ireland there has developed a heightened interest in renewable energy technologies and energy issues in general, associated with concerns about CO_2 emissions, climate change, energy security and peak oil. This has led to the development of a number of third and fourth level degree programmes in Energy Engineering in Irish higher education institutes. UCC for example has been running an MSc programme in Sustainable Energy for 5 years, and has also introduced an undergraduate Energy Engineering degree program. In all these programs, geothermal energy and heat pump technology form part of the curricula.

Commercial and government interest in geothermal energy has also developed in Ireland over the last few years to the extent that the GAI saw the opportunity to organize its 10th anniversary conference in November 2008 entitled 'Geothermal Resources in Ireland - Commercial Opportunities'. In addition, the Irish Government has moved to establish regulatory controls to guide the development of geothermal energy in Ireland, and as the initial step has engaged in a wide ranging consultation process with geothermal stakeholders. This has developed in parallel with Ireland's participation in the EU Altener/IEEA funded Geothermal Regulation for Heat (GTR-H) project to standardize geothermal regulations throughout the EU, which culminated in the GTR-H conference in Dublin in Autumn 2009. Government and commercial recognition of the potential of geothermal energy to aid reduction in CO_2 emissions and dependence on fossil fuel imports can only benefit development of the geothermal industry, and to this end a carbon tax which may be introduced by the Irish Government in its December 2009 budget will further enhance this growth.

6. FUTURE DEVELOPMENT AND INSTALLATIONS

Future projects on the island of Ireland include a 1MW proposed open loop system for heating and cooling the Critical Care Unit of Victoria Hospital in Belfast, and the prospect of including GHP as part of the overall mix for a 20MW energy centre also at Victoria Hospital, Belfast. In addition, investigations are taking place at Cookstown also in Northern Ireland into the feasibility of drilling a deep borehole in limestones to generate an open loop GHP system to heat and cool new buildings to house the Police Service of Northern Ireland (PSNI) and the Fire Training Centre for Northern Ireland. Furthermore, the company which drilled the deep borehole at Newcastle, Co Dublin has recently developed a partnership with Ballymena Borough Council in Northern Ireland with the intention of also exploring the possibility of developing a deep geothermal borehole for a district heating system for the town.

Another large GHP project underway is a 1 MW vertical closed loop system in Dublin to heat and cool the new headquarters of one of Ireland's major banks. Collector systems have been installed in a total of 72 x 200m deep boreholes, but the project is presently suspended due to the current financial position of the bank.

Finally, the Cork Docklands Development Agency, tasked with regenerating the Cork Docklands area, is currently undertaking an investigation into the potential of using open loop heat pump systems to generate district heating for apartment complexes, hotels, shopping malls and commercial premises. The site is a low lying estuarine area subject to tidal influence, where salt water intrusion is a potential problem. Owing to the economic downturn in Ireland, this project is also likely to be delayed.

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