Proceedings World Geothermal Congress 2005
Antalya, Turkey, 24-29 April 2005

Utilisation of Geothermal Resources in the Irish Republic

Sarah O'Connell[1], Alistair Allen[2], Stephen Cassidy[1]

[1] Dept of Mechanical & Manufacturing Engineering, Cork Institute of Technology, Cork, Ireland;. [2] Dept. of Geology, University College Cork, Cork, Ireland

E-mail: sarahoconnell@cit.ie, a.allen@ucc.ie, scassidy@cit.ie

Keywords: heat pumps, low temperature

ABSTRACT

Ireland is impoverished in geothermal energy resources, mainly because it lies outside the sphere of recent Alpine tectonic activity and is distant from plate boundaries. Geothermal gradients in Ireland, based on measurements in deep boreholes, range from 3°C/km to 43°C/km with a mean gradient of 25°C/km. The only recognised geothermal resources within the Irish Republic are 42 documented warm springs in the eastern and southern parts of the country, ranging in temperature from 13-24.7°C, only one of which is exploited. This has been utilised to heat a municipal swimming pool with the assistance of a 100 kW heat pump.

The main geothermal energy development in Ireland is space heating, based on ground sourced heat pump technology, mainly at a domestic level but also encompassing smaller public buildings. One other source of geothermal energy currently being developed is a hydrogeothermal source utilising shallow groundwater in gravels beneath urban areas where the urban 'heat island' effect gives rise to slightly enhanced groundwater temperatures. This source, which also employs heat pump technology for space heating has been successfully employed in a small number of projects in Dublin, and is currently being developed in Cork, where it probably has greater potential for exploitation.

Heat pumps, using ground or groundwater sources, currently number 1500 and represent Irelands burgeoning utilisation of its low temperature resources. Domestic use is the most significant category, with heat pumps in the 12-14 kW size, but there are approximately 20 large-scale installations operating successfully, ranging in size from 19-200 kW. At the present time, total geothermal energy usage in the form of heat pump capacity is of the order of just under 20 MW, but growth in the heat pump market is strong at 45%. Other potential uses of geothermal energy are under investigation.

1. INTRODUCTION

Government policy and interest is in the area of heat pumps with a view to reducing CO_2 and greenhouse gas emissions. Ground-source heat pumps (GSHP) are being targeted as a method of reducing greenhouse gas emissions and so meeting the Kyoto protocol. The Kyoto protocol, set at 13% over 1990 levels, was exceeded in 2000 as shown in Figure 1. Emissions have been exceeded by over 13M tonnes to date. (Dubuisson 2002) The technology is being promoted by the government energy agency, Sustainable Energy Ireland (SEI) as well as at local government level through county and city energy agencies. There are no subsidies for GSHP except for some limited grants available to developers through SEI. The introduction of a carbon tax is expected within the next year. The proposed rate of carbon tax is between €5 and €25 per tonne CO_2. (Howley 2003)

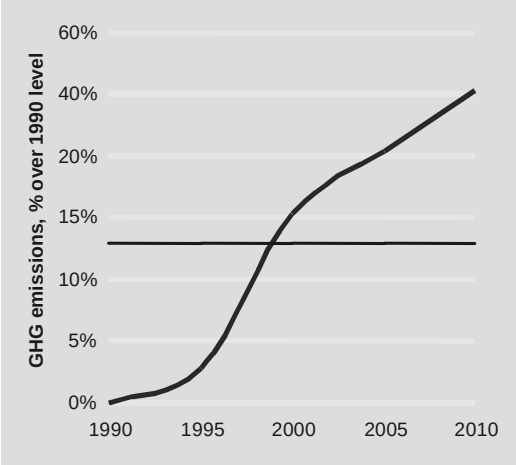


Figure 1. Ireland's Kyoto limit. (Dubuisson 2002)

The lead agencies involved in geothermal energy are the Geothermal Association of Ireland (GAI), Sustainable Energy Ireland (SEI), Geological Survey of Ireland (GSI), 15 energy agencies throughout Ireland, (O'Brien 2001) Irish Association of Hydrogeologists (IAH) and some private companies. The GAI is a voluntary body comprised of interested professionals from geological, engineering and academic backgrounds. Its aim is to promote awareness and use of geothermal energy in Ireland. Of the 15 energy agencies, the most active are in the Cork area. The Cork County Energy Agency is located at the warm springs in Mallow. Geologists from CSA/Conodate, in partnership with GSI and Cork Institute of Technology (CIT) are assessing the geothermal potential and re-interpreting geothermal gradients throughout the Republic. (Goodman et al, 2003) Funding was received from SEI.

2. GEOLOGICAL SETTING

Ireland has limited geothermal energy resources, due to its within-plate setting distant from plate boundaries, and its location well outside the sphere of relatively recent Alpine tectonic activity. Consequently, heat flow values are low, and it possesses no high temperature geothermal resources. In addition, Ireland has not been subject to recent volcanic activity, although Tertiary volcanic activity in the northeastern (UK) part of the island gives rise to higher heat flow values.

Ireland is also devoid of Mesozoic and Tertiary sedimentary sequences, due to extensive erosion associated with the opening of the Atlantic, although in NE Ireland Permian-Tertiary rocks survive beneath Tertiary basalts. Thus, Ireland possesses no young rocks with good primary

porosity, and bedrock mainly consists of Carboniferous or older crystalline rocks, which have been deformed during the Caledonian and Variscan Orogenies (Figure 2). Much of central and southwest Ireland is underlain by Lower Carboniferous Limestones, which are highly karstified, but karstification is probably relatively superficial, and may not penetrate to depths of more than 100-150 m, and possibly much less.

Quaternary glacial overburden deposits of variable character and thickness overlie much of the bedrock in Ireland. Sand and gravel deposits, with good intergranular porosity, occur mainly in the form of eskers and buried valley infillings. Groundwater within them has good potential as a source of low enthalpy geothermal energy.

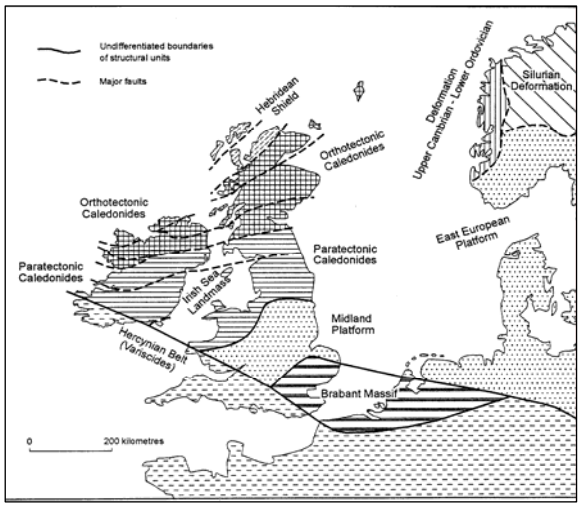


Figure 2. Ireland's tectonic setting

3. GEOTHERMAL RESOURCES

The only recognised geothermal resources within the Irish Republic are 42 warm springs in the eastern and southern parts of the country (Figure 3), ranging in temperature from 13-24.7°C (Goodman et al, 2003). One of these at Mallow, County Cork has been utilised for the past 25 years to heat the municipal swimming pool. Recently, boreholes in the Glanworth area, 20 km to the northeast of Mallow have encountered groundwater at 26°C, and it is intended to determine the source of this groundwater and the possibilities for its exploitation. Groundwater from buried valley aquifers, has been exploited to supply low enthalpy geothermal energy for space heating and cooling (Allen et al, 1999; Allen and Milenic 2003), particularly where the buried valleys pass beneath cities and towns, as groundwater temperatures are enhanced by the 'heat island' effect (Allen et al, 2003). Groundwater in karstified limestone underlying urban areas also has this potential, but to a lesser extent.

4. GEOTHERMAL UTILIZATION

Since Ireland has no high temperature resources, exploitation of geothermal energy is mainly through ground source heat pumps (GSHP). There are approximately 1500 domestic ground source heat pump installations in Ireland, typically in the range between 10 and 14 kW. Over 30 large-scale or commercial systems have been installed. These are detailed in Table 4. Total installed capacity is 19.7 MW_t and thermal energy consumption is estimated at between 51.97 TJ/year to 83.62 TJ/yr.

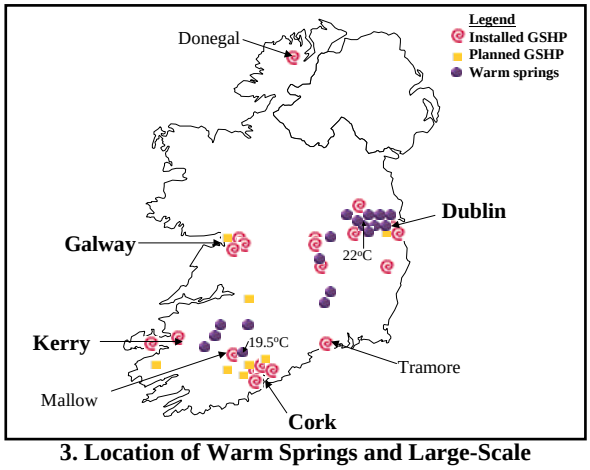
The Irish growth rate is estimated at 45%. Compared with the average European growth rate of 15% (Rivoalen 2001), this is high. The high Irish growth rate is due to the lack of maturity in the market. Until the late 1990's there was only one ground source heat pump company in Ireland augmented by once-off projects. Now there are 10 such companies. In order to prevent the market collapse that occurred in other countries such as Austria and Sweden, an installer training course is being developed. Arsenal Research (Austria), in conjunction with SEI and FÁS, the apprentice training body, aim to pre-empt the installation of poor quality systems through installer certification. (Böeswarth 2004).

Tables 4, 5, 7 and 8 are included in this paper. As Ireland has no high temperature resources, there is no electricity generation or direct heat use. The tables detailing these activities have been omitted.

5. DISCUSSION

5.2 Geothermal Direct Uses

The capacity factor in Table 5 is low due to the mild Figure



3. Location of Warm Springs and Large-Scale Installations in Ireland

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 lowest mean daily minimum temperature in winter is 2.5°C. Average annual ground temperatures are between 8–12ºC (Aldwell 1997). Heat pump installations are designed to operate on the cheaper night rate electricity (7c/unit less) 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 achieved by direct cooling. Direct cooling circulates the brine from the collector in coils or circuits installed in the building ceilings or floors. Reversible heat pumps are not typically used as the ground or water temperature is sufficiently low during the summer to allow direct cooling. The installed capacity is estimated based on projected cooling load for the building. The requirements for air conditioning or summer cooling are less than half the winter heating load. Direct cooling of an IT building in Cork is being considered. This project is exceptional in that it would have a cooling load of several hundred kW larger than the heating load.

Locality	Ground or water temp. (°C)[1]	Typical Heat Pump Rating or Capacity (kW)	Number of Units	Type[2]	COP[3]	Heating Equivalent Full Load Hr/Year[4]	Thermal Energy Used (TJ/yr)	Cooling Energy (TJ/yr)
Domestic Systems Nationwide	8 to 12	10 to 14 (per unit)	1500	H	3 to 4 (mean)	1000 to 1500 per unit	45 - 75 (total)	NONE
TCD, Dublin	13 to 14	450 (total)	6	V Aquifer boreholes	4.8 (mean)	1000 to 1500	1.21 - 1.82 (total)	Not known
UCC, Cork	13 to 17	200	1	V Aquifer boreholes	3.5 (mean)	1000 to 1500	0.51 - 0.77	Direct Cooling
Hostel, Cork	13 to 14	100	1	V Aquifer borehole	3.5 (mean)	1000 to 1500	0.26 - 0.38	NONE
Mallow swimming pool, Co.Cork	19.5	100	1	V Geothermal warm springs	4 (mean)	40,300	10.8	NONE
Co.Clare	8 to 12	55	1	V	4	1000 to 1500	0.15 - 0.22	
Temple Bar, Dublin	14	23	1	V	4.87	1000 to 1500	0.07 - 0.10	NONE
Camp Hill, Kilkenny	8 to 12	30	1	V & O Artesian well & roof tubing	3.5 (mean)	1000 to 1500	0.07 - 0.12	NONE
Churchfield, Cork	8 to 12	34 (total)	2	V & H	2.37 (mean)	5,824	0.41	NONE
Cork	8 to 12	150 (total)	5	H	5 (max)	1000 to 1500	0.45 - 0.6	NONE
Tralee, Co.Kerry	8 to 12	130 (total)	2	H	3.7 (mean)	500 to 750	0.15 - 0.24	Direct Cooling
Carbery, Co. Kildare	8 to 12	46	1	H Direct expansion	6 (max)	1000 to 1500	0.13 - 0.19	NONE
Dolmen Centre, Donegal	8 to 12	45	1	H	3.5 (mean)	1000 to 1500	0.12 - 0.17	NONE
Wicklow	8 to 12	40	1	H	3.5 (mean)	1000 to 1500	0.10 - 0.15	NONE
Kinsale Road, Cork		28	1	H Landfill site		1000 to 1500	0.07 - 0.11	NONE
Dingle	8 to 12	26	1	H		1000 to 1500	0.06 - 0.10	NONE
Nationwide	8 to 12	30 (per unit)	5	H	3.5 (mean)	1000 to 1500	1.93 -2.89 (total)	NONE
Ballyhooley, Co.Cork	8 to 12	19	1	H & O Compost & Air	3.3 - 3.6 (mean)	1000 to 1500	0.048 - 0.073	NONE
Tramore, Co. Waterford	6 to 19	75	1	O Municipal water supply	3.2 - 3.3 (mean)	1000 to 1500	0.19 - 0.28	NONE
Nursing Home, Tralee, Co.Kerry	8 to 12	200	1	V				
School, Tullamore, Co. Offally	8 to12	100	1	H				
TOTAL		20001	1535				51.97 - 83.62	

Table 4. Geothermal (ground source) heat pump

The swimming pool projects in Table 5 use heat pumps not direct heating. Mallow swimming pool is the largest installation and is supplemented by smaller domestic pools. The capacity factor, estimated at 0.317, is larger than the other space heating installations because the heating demands of the swimming pool and showers are much greater.

5.3 Allocation of personnel

The number of professional people involved in geothermal in Ireland is shown in Table 7. The majority work in GSHP

but the CSA/Conodate project has enabled geologists to assess the geothermal potential in Ireland. The rapid growth in the GSHP industry can be seen through the increase in private industry. Before 2000 one company was designing and installing domestic systems. Since 2000 ten

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)	0.15	0.51	0.105
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]	0.2	20	0.317
Other Uses (specify)	NONE		
Subtotal	0.35	20.15	0.211 (mean)
Geothermal Heat Pumps	19.6	51.9 - 83.6	0.084 - 0.135
TOTAL	20	51.97 - 83.62	0.086 - 0.136 (mean)

Table 5. Summary table of direct heat use

more such companies have entered the market. HVAC consulting engineers involved in large projects supplement the smaller design and instillation companies. There is no one person working on geothermal or GSHP in state funded organisations such as SEI and the local Energy Agencies, but over 50% of the enquiries received on renewable energy are regarding GSHP. In Universities and Institutes of Technology, postgraduate research has been done on GSHP and geothermal energy on collector sizing and general assessment of the technology.

Year	Professional Person-Years of Effort					
	(1)	(2)	(3)	(4)	(5)	(6)
2000	1 to 2	NONE	Unknown	NONE	NONE	5
2001	1 to 2	NONE	1	NONE	NONE	7
2002	1 to 2	NONE	2	NONE	NONE	12
2003	1 to 2	NONE	3	NONE	NONE	12
2004	1 to 2	NONE	3	NONE	NONE	13
Total	5 to 10	NONE	9	NONE	NONE	49

Table 7. Allocation of professional personnel

5.4 Total investments in geothermal

The surge in ground-source heat pump usage is reflected in Table 8. Prior to 2000, few GSHP systems were installed. Since 2000 the market has taken off and the estimated investment this required was $16M. Many of the large-scale projects received public funding through SEI or sources such as Leader grants.

No government subsidies exist to encourage installation of GSHP by individual householders, and a general lack of information is a further barrier to overall development of the geothermal sector. In the commercial sector, the main barrier to greater uptake of GSHP is again an absence of government incentives, and in general developers are loathe to undertake the increased capital outlay involved in the installation of GSHP systems, despite the favourable long term economics. However, in Cork, the second city, which is to the forefront of sustainable development in Ireland, an environmentally conscious city council is promoting renewable energy by exerting pressure on developers through the planning process.

Research and Development before 2000 consisted of GSHP postgraduate work in third level institutions. The CSA/Conodate project publicly funded through SEI is the main R&D project on geothermal resources since 1983.

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$	%	%
1990-1994						
1995-1999	0.02		0.5		70	30
2000-2004	SEI FUNDED CSA project		16			

Table 8. Total Investments in geothermal

5.4 Policies / Legislation / Regulatory / Envoirnmental

- National Climate Change strategy aims to reduce GHG emissions by 15 MT/CO_2 by 2012. (SEI 2004) Carbon tax introduction.
- GSHP Installer Certification Training Program. Arsenal, SEI & FÁS.
- Environmental Legislation: Water Framework Directive 2000/60/EC - community water policy including groundwater and will be fully implemented by 2015. Groundwater protection schemes are being developed and implemented by the Environmental Protection Agency (EPA) and GSI. Aquifers and other groundwater used for geothermal projects will be protected from contamination.
- No building codes of practice or standards regulating use of GSHP

6. FUTURE DEVELOPMENT & INSTALLATIONS

Commercial GSHP projects under construction or in planning will add 1MW_t to the existing installed capacity. Geothermal sources for these projects consist of a gravel aquifer, municipal water reservoir, lake source, vertical well pair, an infiltration gallery, horizontal system and an air source heat pump.

Potential demonstration projects for deep geothermal energy are being identified by the CSA/Conodate project. Warm springs and possible aquifers for exploitation will also be proposed. The re-interpretation of geothermal gradients and subsequent geothermal mapping is hoped to provide a platform from which these may be developed.

REFERENCES

Aldwell, C.R.: Low-temperature geothermal energy in Ireland, Seminar on 'Geothermal Energy from Public Water Supply Sources', Tramore, Ireland (1997).

Allen, A.R., Milenic, D.: Low enthalpy geothermal heat resources from groundwater in glaciofluvial gravels of buried valleys. *Applied Energy* , 74, 9-19, (2003)

Allen, A.R, Milenic D., Sikora, P., (2003) Shallow gravel aquifers and the urban 'heat island' effect: a source of low enthalpy geothermal energy. *Geothermics*, 32, 569-578

Allen, A. R. McGovern, C., O'Brien, M., Leahy, L., Connor, B. P. (1999) Low enthalpy geothermal energy for space heating/cooling from shallow groundwater in glaciofluvial gravels, Cork, Ireland. In: Fendekova, M., Fendek, M. (Eds) *Hydrogeology and Land Use Management*. XXIX Congress of International Association of Hydrogeologists, Bratislava, Slovak Republic, IAH, Bratislava, pp 655-664.

Böeswarth, R.: Campaign for the take-off of a self sustainable heat pump market in Ireland, *Geothermal Association of Ireland Newsletter no. 7* (2004)

Building and Energy Management.: Energy Survey Report of Motor Tax Office, Tralee, Co. Kerry. Report for Malachy Walsh & Partners, Cork, Ireland (2001).

Cooper, T.: Use of energy efficient technologies to minimize fossil fuel derived energy in a landmark building. Project report for Green Building Temple Bar. Trinity College, Dublin. (1995).

Directive 2000/60/EC of the European Parliament and of the Council, establishing a framework for Community action in the field of water policy, *Official Journal of the European Communities*, 22.12.2000, L 327 (2000)

Dubuisson, X.: Sun in Action – The Sustainable Energy Revolution, *Proceedings*, Irish Solar Energy Conference, June 2002, Tralee, Co. Kerry, Ireland (2002).

Goodman R. Jones, G., and Slowey, E.: Geothermal Energy Exploitation in Ireland – Review of Current Status and Proposals for Optimising Future Utilisation, Interm Report to Sustainable Energy Ireland (2003).

Howley, M.: Fuel use and distribution in Ireland LIEN – Reporting energy and carbon tax emissions for CO2 trading, SEI Presentation, (2003).

O'Brien, M.: Geothermal and other alternative energy uses in Cork leisure facilities, Presentation to the ILAM, Cork, Ireland (2002).

O'Brien, M.: The development of Geothermal Resources in the Mallow area for Heating Purposes, *Masters Thesis*, Department of Civil Engineering, UCC, Cork, Ireland. (1987).

O'Connell, S. and Cassidy S.F., 'Recent Large-Scale Ground-Source Heat Pump Installations in Ireland, *Proceedings*, IGC2003, Reykjavik, Iceland (2003)

Rivoalen, H.: Heat Pump Market Overview in Europe, Report for EDF Research and Development group on Heat Pumps, Air Conditioning and Indoor air quality (2001).

SEI website:www.sei.ie