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Low-enthalpy geothermal energy resources from groundwater in fluvioglacial gravels of buried valleys

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Abstract

Low-enthalpy geothermal energy can be generated from groundwater in gravels infilling buried valleys formed during the Pleistocene glaciation, when the sea level was significantly lower than at present. Where buried valleys underlie floodplains of present-day rivers, flowing through major cities, a 'heat island' effect can generate slightly enhanced temperatures in shallow groundwater. This groundwater can be utilised for space heating buildings by passing it through a heat pump, and the chilled water then used as a heat exchanger to satisfy cooling requirements of the building. For flow rates of 20 l s^{-1}, and a temperature reduction of 8 °C in the heat pump, a 672 kW heating resource can be generated, sufficient to heat buildings of 11,000 m^2 floor area. A cooling resource of 336 kW is also available. Potentially, this geothermal resource could be utilised without the 'heat island' effect. Cost of the development is minimal and long-term economic benefits are significant.

Keywords: Low enthalpy geothermal energy; Buried valleys; 'Heat island' effect; Groundwater; Gravels; Space heating/cooling; Heat pumps

1. Introduction

Over the last decade, continued uncertainty in Europe over the stability of oil and gas prices and supplies has brought about the rapid expansion in development of sustainable energy resources. Initially triggered by the 1973 oil crisis, development of alternative energy sources has not been as rapid as might have been expected. Only recently, due to major environmental concerns over atmospheric pollution, as

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embodied in the Rio and Kyoto Accords, has a serious commitment to sustainable energy emerged.

Of the various sustainable energy sources, common forms which may be in abundance, e.g. wind, wave or hydroelectric, are generally expensive to develop and may have negative environmental impacts. Geothermal energy, on the other hand, is one of the easiest to exploit and can be readily developed due to the relatively simple technology involved. Also, being mainly in the form of hot water and steam, it can be directly utilised as a heating resource, but can also be converted into electricity. High-enthalpy geothermal energy is mainly associated with plate boundaries and other tectonically active areas, Neogene volcanic zones or areas which have been tectonically active within the relatively recent geological past, i.e. <50 Ma. Most of southern and central Europe, which lies within the sphere of Alpine or younger tectonic activity, has abundant high-temperature geothermal resources. On the other hand, apart from Iceland, the geologically older, tectonically-inactive regions of northern Europe possess no high-temperature geothermal energy resources.

Low-enthalpy geothermal resources, generally in the form of tepid (11.5–13.5 °C) or warm (13.5–25 °C) springs, representing artesian groundwater which has risen rapidly to the surface from significant depths, are much more widespread geographically, but have fewer applications, and generally are not suitable for conversion to electricity. They can, however, be used for space heating and are also commonly employed in agriculture, especially horticulture, aquaculture, some industrial processes and for balneological-therapeutic purposes. This presentation, however, considers even lower temperature groundwater resources, only a few degrees above background values, which are present in abundance beneath many present day rivers, and cities built upon these rivers.

2. Irish energy resources

Ireland is endowed with limited traditional energy resources. Coal occurs only in rare thin seams sporadically developed in a few localities. The Irish traditionally relied on wood for heating, and subsequently, after wood had been depleted, on peat. Latterly, peat has also been burned in power stations for electricity generation. Unlike its neighbour the UK, Ireland has been unsuccessful in locating oil in its surrounding offshore basins, and apart from a medium-sized gas field off the south coast and a potentially exploitable new gas field off the west coast, it is relatively destitute in oil and gas reserves. Furthermore, due to a low relief and relatively flat topography, Ireland possesses limited hydroelectric potential, and although endowed with abundant wind and wave energy resources, has been slow to develop these. Currently, wind energy is being strongly promoted and under rapid development in Ireland, but wind farms are expensive to develop and visually intrusive. Ireland also has huge wave-energy potential but there has been little government investment in research.

Ireland has relatively abundant and extensive groundwater resources, since much of the country is underlain by karstified limestone of Carboniferous age. However,