Hidden Deep Geothermal Potential—Republic of Ireland*

Nick O'Neill[1]

Search and Discovery #80328 (2013)**
Posted October 31, 2013

*Adapted from article published in AAPG European Region Newsletter, June, 2012. Appreciation is expressed to AAPG European Region Council, Vlastimila Dvořáková, President, their Editorial Board, Karen Wagner, Chief Editor, James Bailey and David Contreras, Coordinators, William Sassi, Coordinator of R&D Projects, and Jeremy Richardson, Office Director, AAPG European Region.

[1] SLR Consulting Ireland, 7 Dundrum Business Park,Windy Arbour, Dundrum, Dublin 14..

Introduction

Leading environmental firm SLR Consulting has completed an analysis of the deep geothermal resources of the Republic of Ireland on behalf of the Sustainable Energy Authority of Ireland (SEAI). The Play Fairway Analysis assessed the geothermal exploration risk by analysing the various attributes of the subsurface of Ireland to a depth of 5000 metres. The series of geothermal resource risk maps published by SEAI will advance the exploitation of geothermal energy in Ireland for district heating and to generate low-carbon electricity. The results from the Play Fairway Analysis will encourage more exploration companies to get involved, increasing investment in exploration and the likelihood of success in the development of geothermal resources in Ireland.

Geothermal energy, the energy stored in the form of heat below the earth's surface, has been used for space heating and bathing since Roman times. More recently geothermal resources have been used for the supply of hot water for district-heating schemes, including for houses, agriculture, horticulture and industrial applications as well as to generate electricity. Geothermal-generated electricity was first produced at Larderello, Italy, in 1904 (Figure 1). Geothermal energy is a renewable resource that does not consume any fuel or produce significant emissions. Deep geothermal resources are usually found below 1000m and are commonly subdivided into hydrothermal and Engineered Geothermal Systems (EGS).

Some locations, like Iceland, Indonesia, New Zealand, USA, Italy, and the Philippines, have elevated geothermal heat flow with temperatures of over 150ºC at 1 km because they are located at geological plate boundaries that are generally also active volcanic zones. Most locations, like Ireland, have rock temperatures of around 35ºC at 1km.

In Europe hydrothermal resources are present in deep aquifers with enhanced temperatures where heat can be easily extracted due to the presence of water as a heat transfer medium. Doublet hydrothermal systems produce hot water from a production well and re-inject to the aquifer using an injection well. Single borehole hydrothermal systems can use a closed loop heat transfer system contained within a single borehole (Figure 2). For example, doublet hydrothermal systems near Paris (France) extract 73ºC geothermal heat from depths between 1800m and 3500m for district heating (Figure 3). EGS systems are applied at depths in excess of 4000m in areas where there are no natural aquifers. These systems are more experimental but have future potential for broad application in high-temperature power generation.

There are three basic technologies for generating electricity from geothermal energy. Dry steam power plants and flash steam power plants can use water from the geothermal production well at temperatures greater than 182°C. Binary cycle plants use geothermal water below 100°C to heat a „working fluid‟ such as iso-pentane, which is vaporised and used to turn turbine/generator units and is the technology that will be needed to generate electricity from Ireland‟s low-enthalpy geothermal resource.

Geothermal power projects are characterised by high capital investment for exploration, drilling wells and installation of plant, but this is balanced by subsequent low operating costs because of the low marginal cost of fuel.

Play Fairway Analysis --Ireland

The recently completed Play Fairway Analysis will reduce the cost of geothermal exploration drilling in Ireland by reducing the geological risk of finding geothermal resources.

The 2500m-depth geothermal resource map of Ireland produced by SLR indicates potential for hydrothermal resources for direct use in district heating/cooling schemes, using temperatures in the 65ºC to 80ºC range, assuming adequate aquifer capacity is present. The 5000m depth geothermal resource map indicates potential for electricity generation in a number of potential „hot-spots‟ in the Lough Allen Basin, the Larne - Lough Neagh Basins and the Rathlin Basin. This potential is indicated by combining the heat resource map (Figure 4) and the geothermal exploration risk map (Figure 5).

Play Fairway Analysis (PFA) is an assessment of exploration risk on a geological basin scale used by the oil exploration industry. An oil exploration PFA involves the integration of key geoscience information (log, core, seismic, geochemical, test data, etc.) into a model of the history of the evolution of sedimentary basins over geological time and the critical, qualitative, and three dimensional examination through analytical techniques of the petroleum potential of these basins.

This study was a first attempt to apply this technique to the analysis of the geothermal potential of Ireland. The geoscience database includes;

- borehole data deeper than 500m;
- regional gravity data;
- modelled rock temperature at 5000m and 2500m;
- modelled temperature of warm springs;
- aeromagnetic data;
- onshore seismic lines;
- significant geological basins;

- regional structures;
- granite outcrop and interpreted buried granite.

This key geoscience information is integrated into geographic information system GIS layers in MapInfo.

The PFA, carried out at the sedimentary basin scale, examines the full sequence of rocks in each basin. For each basin the qualitative risk of finding a heat source, an insulator and a reservoir is assessed as low, medium or high. Figure 6 shows the colour codes for the different levels of risk used on the maps. The green areas on the maps are sedimentary basins where the parameter (e.g., heat source) is more likely to be present than absent. The light orange areas on the maps are sedimentary basins where there is significant uncertainty that the parameter (e.g., reservoir) is present. The light yellow areas on the maps are sedimentary basins where the parameter (e.g., insulator) is more likely to be absent than present. On Figure 7 (Map 20) the green areas are sedimentary basins where the combined risk of finding source, reservoir and insulator is relatively low (i.e., a geothermal prospect is more likely to be present than absent). Where structural trends occur within green areas, the geothermal prospect risk is further reduced.

Using a table the sedimentary basins can be ranked in terms of their overall geothermal potential risk.

The Sustainable Energy Authority of Ireland funded this research and development into geothermal resource assessment in Ireland. Further information can be found at http://www.seai.ie/Renewables/Geothermal_Energy/Geothermal_Maps/. SLR provided geological exploration and drilling operations support to GT Energy Ltd when they drilled to over 1.4km in Newcastle area of South County Dublin in the first deep drilling project to investigate hydrogeothermal potential for district heating and low temperature electricity generation in Ireland. Working on behalf of GT Energy Ltd, SLR scoped, prepared and submitted the planning application along with the environmental impact statement for the development and operation of the first geothermal electricity generation plant in Ireland. Planning permission was granted by South Dublin County Council within just four months with no third party appeals against the decision. SLR Ireland Managing Director Tim Paul said: “The comprehensive scoping and pre-planning consultation carried out in conjunction with GT Energy Ltd, together with the high quality of the application documentation, combined to ensure a successful planning decision in a very short time frame”.

Website

Substainable Energy Authority of Ireland: Website accessed April 8, 2013.
http://www.seai.ie/Renewables/Geothermal_Energy/Geothermal_Maps

Figure 1. Larderello standard unit of 20MW dry steam electricity generating power plant – Italy (Source: SLR, unpublished, 2010).

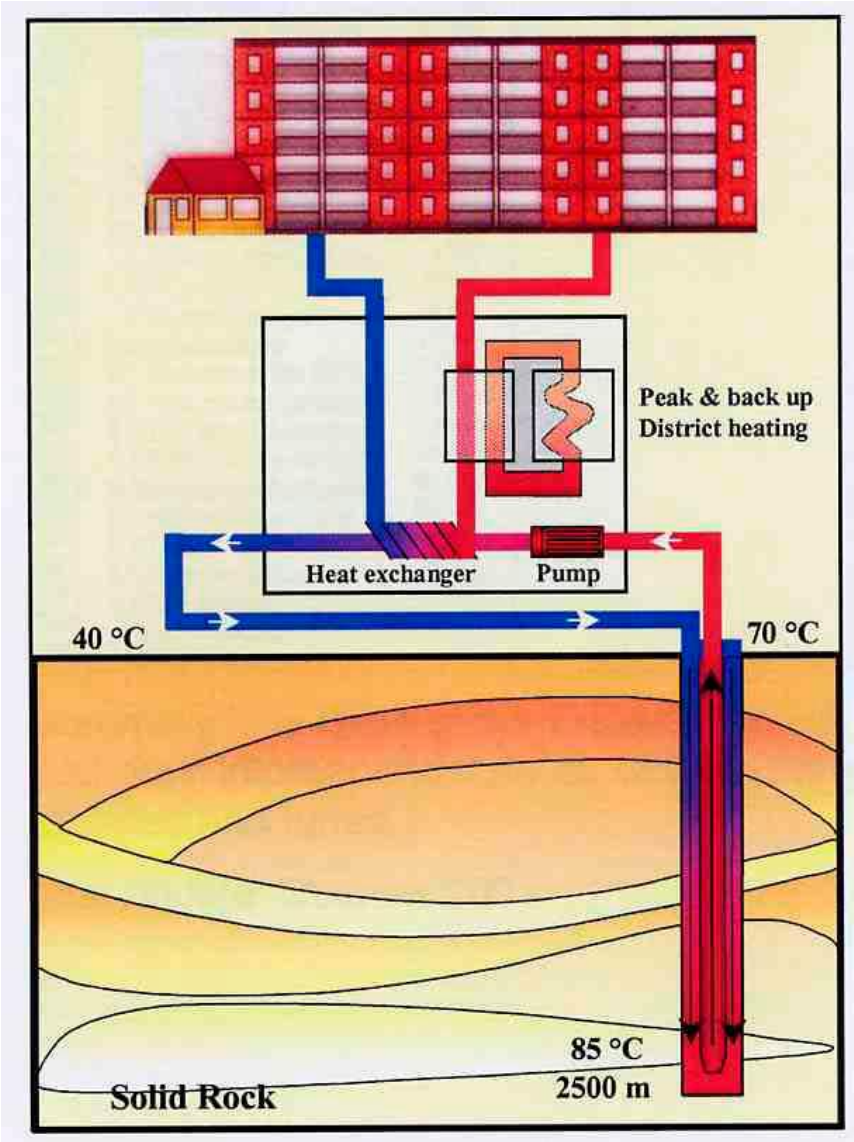

Figure 2. A 2.5 km-deep geothermal well in Germany combined with a geothermal heat exchanger located on the surface can cool and heat a building by means of a closed water cycle. Water at 2.5km depth measuring 80ºC is recovered at 70º on surface and passed through a heat exchanger, where 30º is extracted to heat and cool buildings. The technology makes it possible to reduce the carbon dioxide emission rate by over 130 tonnes per year. With a peak capacity of 450 kW, the heat exchanger is able to provide the heat and cooling supply for about 200 single-family houses. (Source: Super C Project, RWTH Aachen, Germany, 2010.)

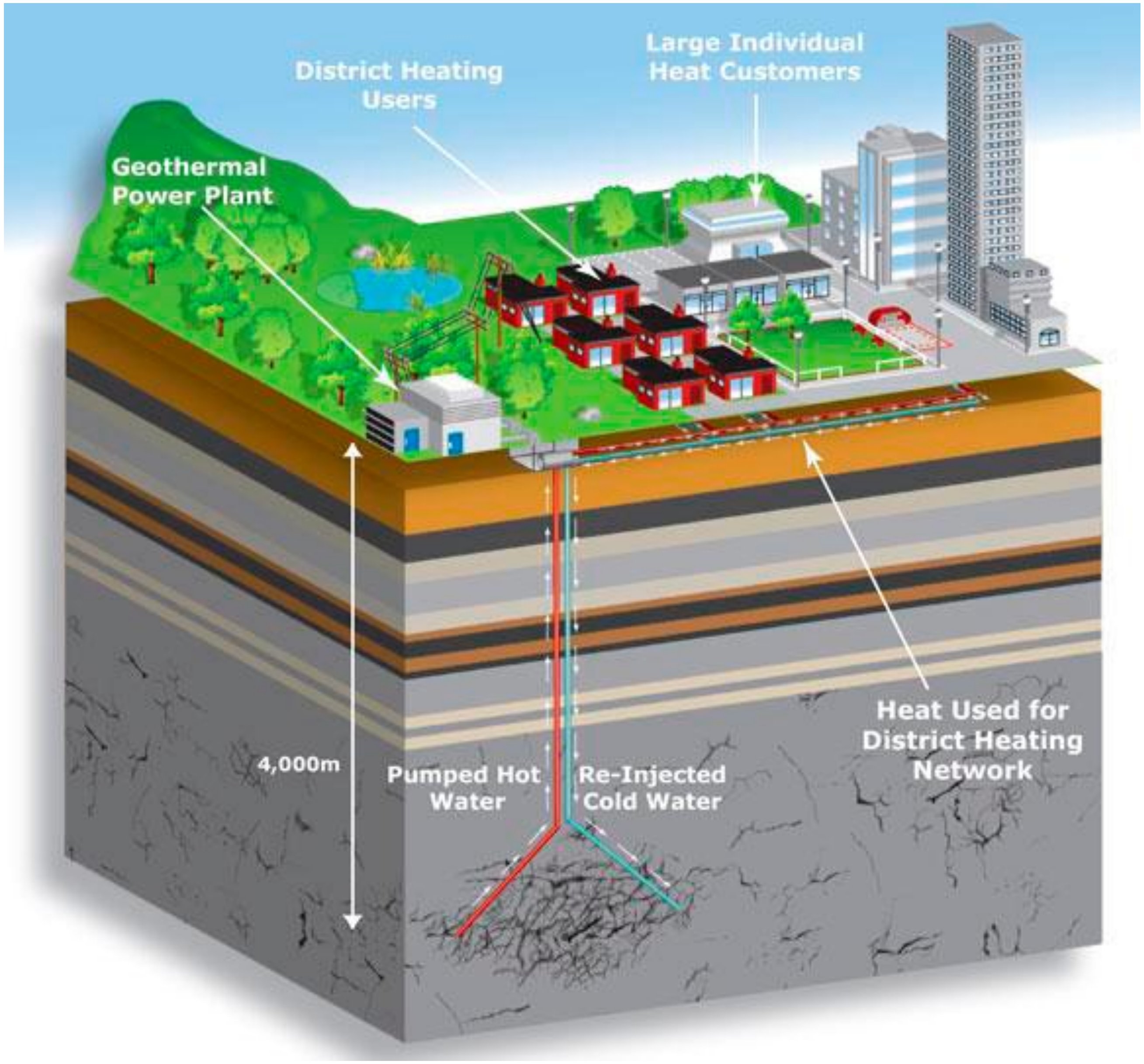

Figure 3. Diagram showing an open hydrothermal system that delivers electricity and district heating (Source: GT Energy, 2010).

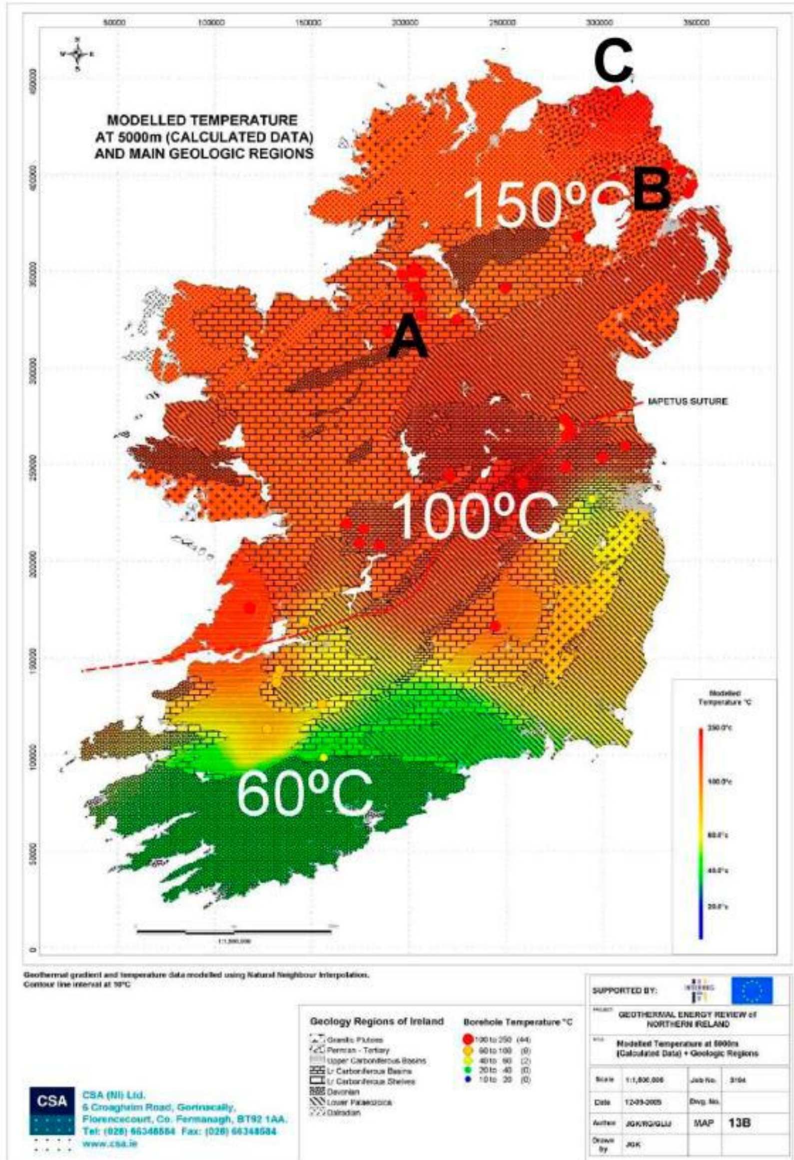

Figure 4. Regional Modelled Temperature at 5km depth (from Goodman et al., 2004). Note that locally these temperatures may be significantly different. A = Lough Allen Basin; B = Larne - Lough Neagh Basin; C = Rathlin Basin.

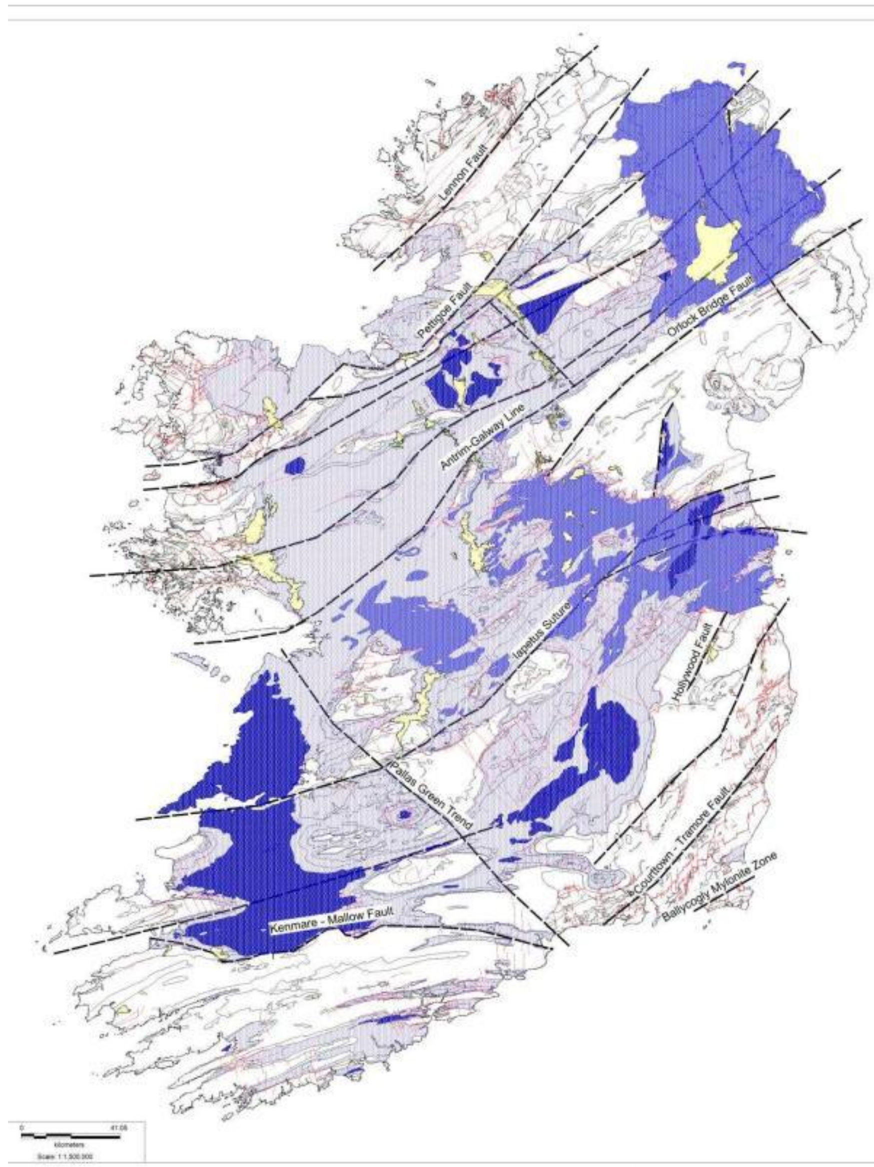

Figure 5. Geothermal exploration risk in the Carboniferous basins of Ireland. The area in dark and medium blue indicate potential lower risk because of the presence of insulating shales and possible deep fractures providing transmissivity (Source: SLR, in preparation).

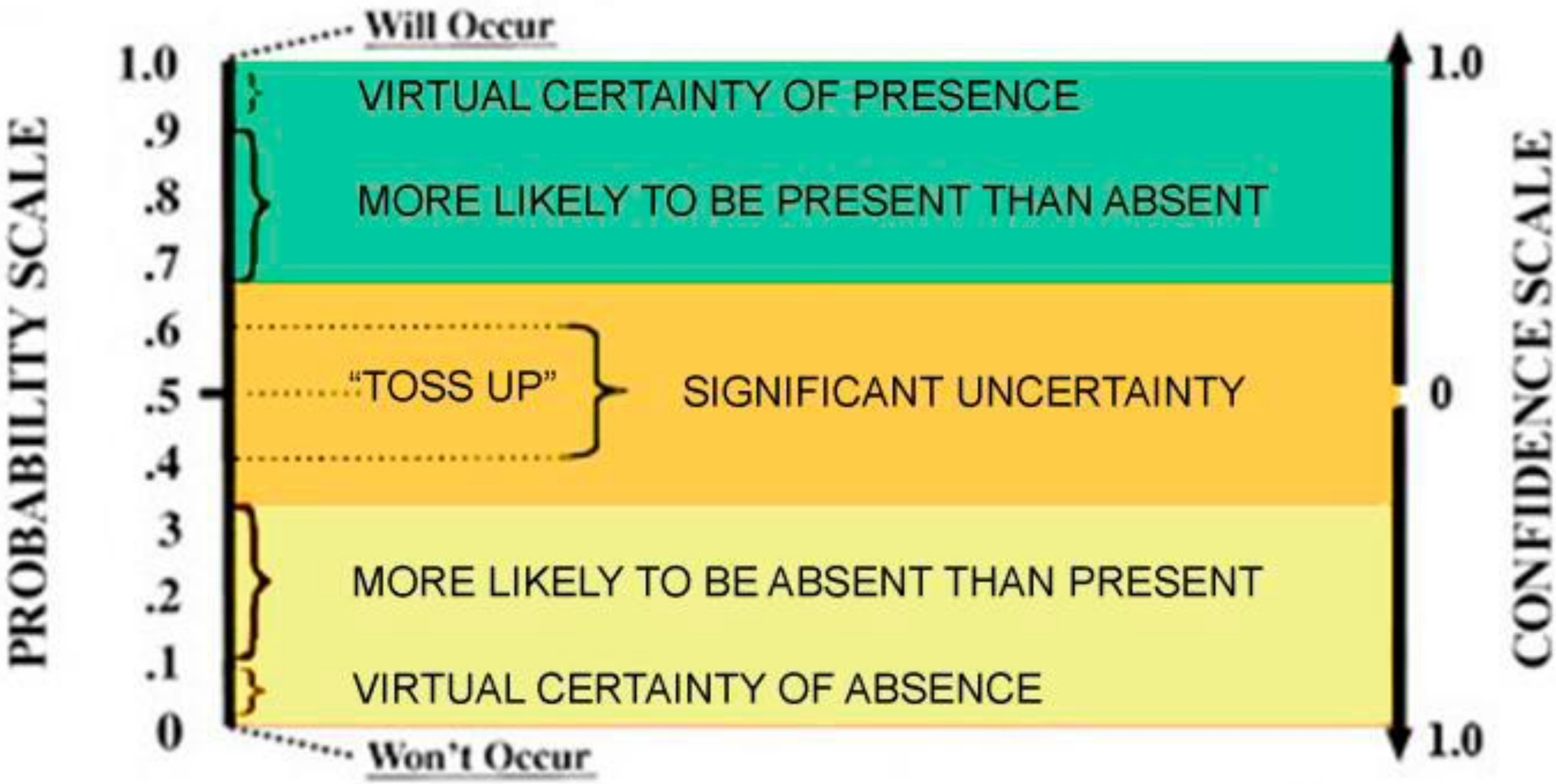

Figure 6. Probability scales and risk colour codes used in this PFA.

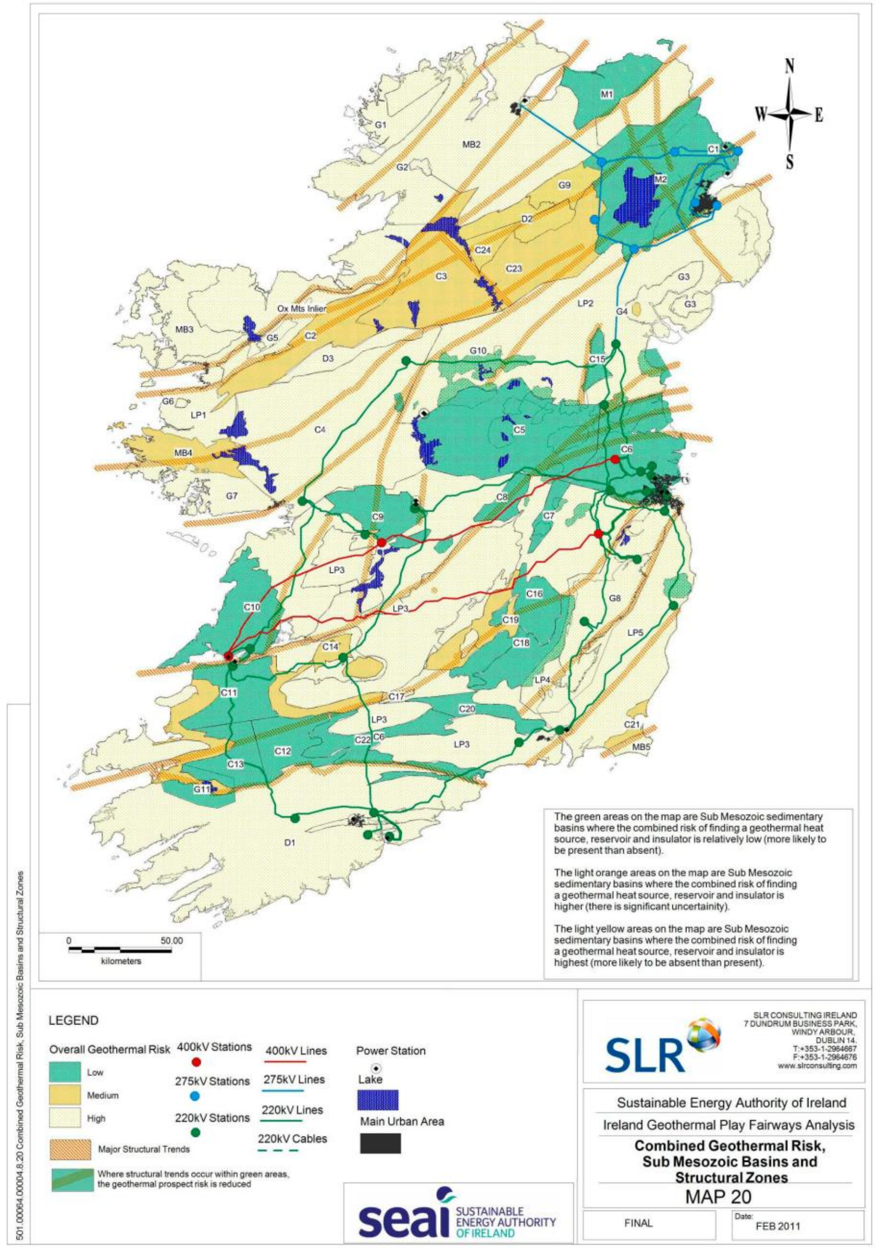

Figure 7. Combined geothermal risk, sub-Mesozoic basins and structural zones.