D2.1.

A Geothermal DH map

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Output description:
The objective is to present an online web-map viewer (WMV) which shows areas within the targeted countries where

- the geothermal potential is suitable for district-heating
- there is an existing heat demand (heat-market analysis)
- matching supply and demand, i.e. those areas where the geothermal potential is good and it can be harvested by existing demand

The aim of the WMS is to show these areas at a macro-regional scale, to outline prosperous regions for future investments in geothermal district heating and thus raise awareness of the policy makers, present and potential investors of the large – at the present not utilized – geothermal potential for DH in Europe. The resolution of the tool was determined by the available datasets (see chapter “Methodology”) thus the scales of the maps used imply that the Geo-DH WMV provides a large-scale overview for the district heating geothermal potential and should not be used for local assessments. In this way the delay in delivery (i.e. not presenting it at the national workshops) did not impede the overall project performance, as local authorities at national levels would need more detailed information.

Methodology:
First the geology-related criteria had to be defined, i.e. those boundary conditions which make a geothermal reservoir suitable for district-heating. For a simple approach only 2 parameters were considered: temperature of fluid (thermal groundwater) > 50 °C, and high yield (normally several thousand l/min). Due to the great variety of thermal aquifers at a European scale, it was not possible to quantify exactly yield limits values, therefore those geological situations were considered, where such permeable reservoirs may exist: i.e. (1) Neogene basins with thick porous sedimentary sequence infill and (2) large, preferably active tectonic zones where enhanced permeability may exist in deep-lying carbonate / crystalline rocks.

As the aim of the project is to give a uniform evaluation for all Geo-DH countries, only those datasets could be used for evaluation, which contain harmonized data for all targeted countries. These are typically pan-European maps at a scale of 1: 1 000 0000 to 1. 5 000 000, showing the geology, hydrogeological conditions and subsurface temperature distributions. The content of the maps was amended, where relevant by information on reservoirs at a country-scale, like from national geothermal atlases (Slovakia, Poland), country update reports, etc.

Current status of the Geo-DH WMV:
The WMV is available at: http://loczy.mfgi.hu/flexviewer/geo_dh. After its finalization it will be directly linked to the Geo-DH project portal, but till that it is publicly available for all interested people via the above link (running on the web-map server of the Geological and Geophysical Institute of Hungary).

Clicking on the link we arrive to the WMV, a welcome window pops up with a short introduction on geothermal district heating (Fig. 1). There is an additional short information (user’s guide) on how to use the WMV.

By clicking on the bottom box (“OK, let’s go to the map viewer”) we arrive to the WMV itself. At the top right corner there is a list of layers which shows the currently available thematics. By switching on/off the little OK symbols in boxes, the different layers can be activated/de-activated. By clicking on the little triangles right to the thematics, we can change the transparency of the picture, and there will be a short description of each map (these specific map descriptions are already prepared (see Annex of this report), their technical implementation into the WMV will be done within the coming days).
On the left-side of the screen, there is a scroller, with which we can enlarge the picture (also with the + and – signs), by clicking on the pan (little hand) we can grab and shift the picture (Fig. 2).

By clicking on the little triangles left to the thematics, the different layers’ thematics become visible, such as heat-flow density (Fig. 3), temperature at 1000 m depth (Fig. 4) and temperature at 2000 m depth (Fig. 5).
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Fig. 3 Heat-flow density

Fig. 4 Temperature at a depth of 1000 m
Fig. 5 Temperature at a depth of 2000 m

Within the thematic layers based on the interpretation of the geological map of Europe (will be incorporated after clarifying copyright) Neogene basins were outlined within the Geo-DH countries, where porous reservoirs are supposed to be present (Fig. 6)
Fig. 6 Outline of Neogene porous potential reservoirs (yellow patches)

By adding the layers “Geothermal data in Neogene basins” those areas are outlined where within the sedimentary basins temperature is above 50 °C at a depth of 1000 m, above 90 °C at a depth of 2000 m, and heat-flow density is above 90 mW/m² (Fig. 7). A detailed legend showing these categories will be added to the map.

Fig. 7 Neogene basins where temperature is above 50 °C at a depth of 1000 m, above 90 °C at a depth of 2000 m, and heat-flow density is above 90 mW/m²

Furthermore the currently existing Geo-DH plants are added: by clicking on the site, a small information window pops-up with basic data of the plant (Fig. 8).
Data collection and reasons of delay

The first exercise was to collect the available geological information from the different partner countries. Firstly, a questionnaire (modified from the Geoelec data acquisition form) has been prepared and sent out to: Geo-DH partners, EGEC national contact points, IGA country update authors, Geological Surveys national contact points and members of GeoEnergy Expert Group (via EuroGeoSurveys). Despite the high number of sent requests, there was a very poor feedback, so it became obvious that we have to base the creation of the WMV on publicly available pan-European maps.

Originally it was planned that there would be a strong input on the resource (geothermal-potential related) side from the Geoelec project. However due to delays in Geoelec it did not happen, also a reason for delay in Geo-DH.

Thirdly all available maps to be incorporated into the WMV for further evaluations (maps from the Geothermal Atlas of Europe, geological and hydrogeological maps of Europe) were available only in hard-copy format. First they had to be scanned and then geo-referenced to be able to incorporate into an ArcGIS system, which serves the basis for the WMV. This digital transformation of the maps was a time consuming process.
ANNEX: Description and references to maps (to be incorporated into the WMV)

The **Geological Map of Europe and Adjacent Areas** (IGME 5000) shows the main geological units (sedimentary, igneous and metamorphic) by a color code and abbreviation indicating the geochronological age of the rocks, as well as the main tectonic elements (different types of faults, thrusts). It made possible to outline the contours of the large sedimentary basins, major tectonic zones with active deformation where natural faults and fractures as preferential pathways for deep convective hydrogeothermal systems may exist, as well as young volcanoes.

Reference:
International Geological Map of Europe and Adjacent Areas (IGME 5000) 1:5 000 000

The **International Hydrogeological Map of Europe** (BGR 2008) provides a categorization of rocks according to their hydrogeological properties being classified to porous and fissured aquifers (with highly and moderately productive sub-classes), as well as insignificant aquifers. It made possible to outline areas where hydrogeothermal applications can be excluded (insignificant aquifers), as well as those regions which may serve as major recharge areas for deep-seated porous or fissured aquifers, potential hydrogeothermal reservoirs.

Reference:
International Hydrogeological Map of Europe 1: 5 000 000 (2008) – BGR Hannover / EGS Brussels / UNESCO Paris

**Temperatures at a depth of 1000 m and 2000 m**

Knowledge of temperature at a drillable depth is a prerequisite for geothermal exploration. The maps showing the temperature distribution at various depth (Hurter and Haenel, 2002), made it possible to outline areas where temperature is higher than 50-60 °C at a depth of 1000 m, and above 90-100 °C at a depth of 2000 m. A more detailed and up-to-date modeled subsurface temperature distribution was prepared by the Geoelec project and is available at www.geoelec.eu, showing temperature variation down to a depth of 5 km.

Reference:

**Heat-flow density**

Terrestrial heat-flow density describes the vertical transport of heat by conduction in the Earth's crust, which is depending on the thermal conductivity of the rocks (in W m⁻¹K⁻¹).
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measured on core samples or drill cuttings), and the geothermal gradient (K/m, obtained from temperature logging in boreholes). The content of the map was amended, where relevant (also considering the thickness of the lithosphere) after Cloetingh et al. (2010). It made possible to outline areas where with high heat-flux, i.e. where heat-flow density exceeds 90-100 mW/m².

References:


**Porous aquifers within large sedimentary basins**

The map shows those areas where in large sedimentary basins the sediments thickness is expected to be larger than 1500-2000 m, natural permeability is assumed to be high enough to produce thermal water from wells without pumping and temperature exceeds 50-60 °C at a depth of 1000 m and 90-100 °C at a depth of 2000 m. Due to the compaction of sediments, prosperous reservoirs with sufficient permeability within porous sedimentary rocks are not expected to exist deeper than 2-2,5 km below the surface.

References:

International Geological Map of Europe and Adjacent Areas (IGME 5000) 1:5 000 000

**Fractured reservoirs**

The map shows those areas, where there is a possibility for existence of fractured porosity in deep-lying carbonate / crystalline rocks within those areas where subsurface temperature exceeds 50-60 °C. The areas were outlined based on considerations of various tectonic models showing large structural zones, margins of major tectonic blocks, areas of active deformation and natural seismicity, as well as thematic information (where available) on deep-seated basement reservoirs.
References

