Main European Geothermal District Heating Sites

GEOTHERMAL DISTRICT HEATING

European Geothermal Energy Council

Reykjavik today geothermal district heating

Background

District heating – DH – is a system which distributes heat from a centralised generation plant to end (residential, tertiary, commercial, recreational facilities…) users, connected via a heating grid and substations. DH has replaced, in most instances, traditional central heating systems where each building is heated by an individual boiler.

Clearly, DH achieves higher energy, economic and environmental performance. Heat supply is best adjusted to users demand. Individual building boilers are replaced by a heat exchanger three way valve piping outfit, fuel supplies and operation/maintenance are optimised, all factors resulting in significant cost savings. Last but not least, it reduces greenhouse gas emissions and excess heat losses, thus securing upgraded environmental control.
As of early 2000's European DH market penetration stands as follows (percentage of district heated houses) : Iceland: 96%; Baltic States / Poland / Sweden / Denmark / Finland: 50-60%; Austria / Germany: 12-15%; UK/Netherlands: 1-4%.

This record reflects (i) the fact that Iceland enjoys abundant geothermal resources added to a consistent energy policy of the state in favour of energy savings and renewable energy sources (RES), the latter adopted by Scandinavian, Baltic and Polish states, and (ii) an almost negligible DH share in the UK and Netherlands, most likely attributed to an adverse natural gas lobby competition and, at a lesser extent, to milder climatic conditions.

Despite its "modernity" DH is nothing new. As a matter of fact, it dates back to Roman ages as witnessed by remnants evidencing city homes and baths heated via natural hot water catchments and piping. At Chaudes Aigues, in Central France, a city DH system, pioneered in year 1330, fed by the Par hot spring at 82°C, is still operating to date. Heated homes were charged, in those times, a tax by the local landlord in exchange of maintenance duties, as reported in the city annals.

Chaudes-Aigues, PAR spring (exploited since 1330 AD)

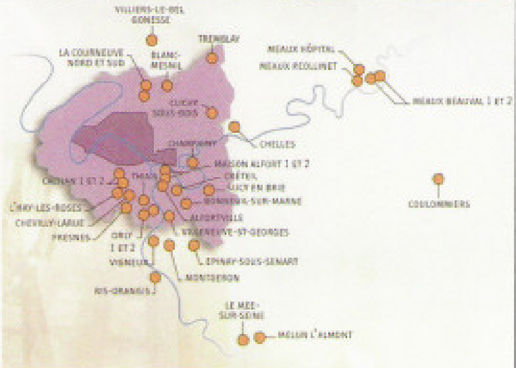
Noteworthy is that these early DH systems could be completed thanks to local hot springs and shallow wells, i.e. (sub)surface evidence of geothermal heat conveyed by water.

So, everything considered, engineering of geothermal district heating – GDH – ambitions nothing more than revisiting DH sources. However, no way does this "revival" imply a geothermal archaeological itinerary, but a thorough technological accomplishment instead.

Status

GDH represents 35% of the European installed power dedicated to direct uses, i.e. an online capacity nearing 5,000 MWt. Major GDH sites (over 35 exceeding 5 MWt capacity) highlight the dominant role played by Iceland and Turkey, two countries enjoying favourable, volcanically and tectonically active, geodynamic settings on the Mid Atlantic Ridge and the Aegean façade/Anatolian plateau respectively, demonstrating also relevant entrepreneurial skills. The two largest schemes address the heating of the city of Reykjavik and of the Paris suburban area.

GDH provides almost the whole of the Reykjavik demand with an installed capacity of 830 MWt serving 180,000 people, 60 million m³/yr of water at an average 75°C (user inlet) temperature. The city grid elsewhere exhibits several distinctive features compared to most of its European replica. An important part of the hot water supply is piped from distant wells and there is no injection whatsoever of the heat depleted water (ca 35°C) underground.



Location of Paris Basin geothermal district heating doublets

The Paris Basin GDH system is based on a dependable sedimentary resource environment and on the doublet concept of heat extraction. Here, hot waters at an average 70°C temperature are hosted in permeable carbonate rocks (the Dogger limestone reservoir) at depths of 1500 to 1800 m. The geothermal fluid, a hot saline brine including a solution gas phase, is pumped to surface from a production well and the heat depleted brine pumped back into the source reservoir via an injection well; the doublet well spacing is designed in order to avoid premature cooling of the production well.

The thirty-four geothermal doublets (and as many heating grids), operating since the early 1980's in the Paris area, totalise installed power and generating capacities of 230 MWt and 1,000 GWht/yr respectively and serve over 100,000 equivalent dwellings, each 70 m² in area. They achieve the savings of 500,000 tons of CO_2 emissions.

Oradea, in Western Romania, is an example of the insertion of a geothermal heating system into the existing city, coal fired/back pressure, combined heat and power (CHP) network, typical of previous Central/Eastern Europe district heating practice. Eleven geothermal wells (2500-3450 m; 72-106 °C), among which two doublet arrays, are serviced for heat and sanitary hot water – SHW – supply amounting to ca 100,000 MWht/yr, via the CHP grid substations.

Technology outlook

Worth recalling is that a GDH system has to comply with variable heat loads and existing building designs and heating modes. These conditions become acute for low outdoor temperatures (peak loads) and conventional, temperature demanding, heaters (such as cast iron radiators). Therefore base load supply and retrofitting are the rule.

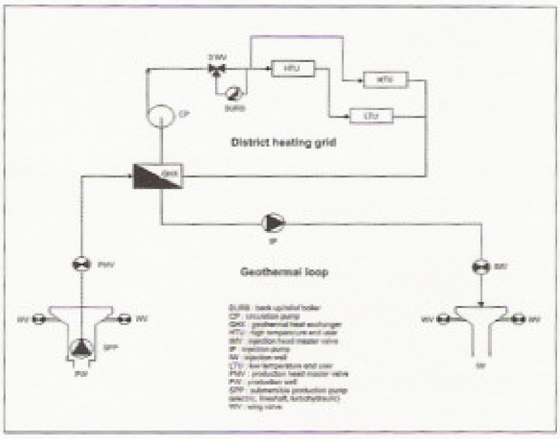
With the exception of Iceland, another prerequisite prevails respective to the geothermal resource to heat load adequacy. Both resource and demand need to be geographically matched.

The two major components of a typical GDH grid are the geothermal loop and heating grid mains, interfaced by the geothermal heat exchanger.

Modern doublet designs (in known areas) include two wells drilled in deviation from a single drilling pad. Bottomhole spacings are designed to secure a minimum twenty year span before cooling of the production well occurs.

Well depths (deviated) of 2000 to 3500 m are not uncommon; often located in sensitive, densely populated urban environments, they require heavy duty, silent rigs (up to 350 tons hook loads, diesel electric drive).

Similar environmental constraints apply to periodical well maintenance (workover) operations which occasionally take place in landscaped sites. Fiberglas lined production/injection wells, first completed in 1995, are a material solution to steel casing corrosion. Continuous downhole chemical inhibition lines are another alternative to defeat corrosion/scaling shortcomings in hostile thermochemical environments.



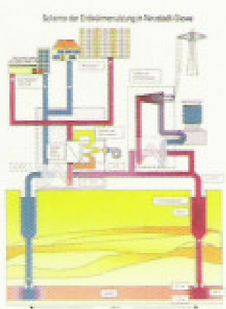
GDH conceptual design

Geothermal fluid production is usually sustained by artificial lift, i.e. submersible, variable speed drive, pump sets of either the electric or (enclosed) lineshaft type. Whenever self flowing production may be substituted, low well head pressures and subsequent escape of solution gases require the installation of a degassing/abatement unit. To combat corrosion damage and ease periodical cleaning, geothermal heat exchangers need to conform to titanium plate design and manufacturing.

Heat pumps

Back up heat, below outdoor transition temperature (5 to 10 °C), can be supplied partly by heat pumps and totally by boilers.

Heat pumps of the water/water type may upgrade geothermal heat recovery, from heat exchange alone, by depleting rejection temperatures and boosting grid distribution temperatures downstream from the geothermal heat exchanger. Accordingly, various heat pump configurations may be contemplated and heat pump units combined in either serial, parallel or hybrid modes. In several instances (Denmark, Germany, Iceland) absorption heat pumps, often associated with geothermal Combined Heat & Power plants (CHP), have been successfully implemented.



Neustadt-Glewe CHP Schematic

District cooling

Geothermal district cooling is actually poorly developed in Europe, hardly 30 MWt installed cold power. This development issue which could provide additional summer loads to GDH systems should therefore be challenged by geothermal operators (and users).

Cooling based on absorption chillers (heat pumps), using water as a refrigerant and lithium bromide

(or ammoniac) as an absorbent seems an appropriate answer, provided minimum geothermal temperatures stand above 70 °C. The refrigerant, liberated by heat from the solution produces a refrigerant effect in the evaporator when cooling water is circulated through the condenser and absorber.

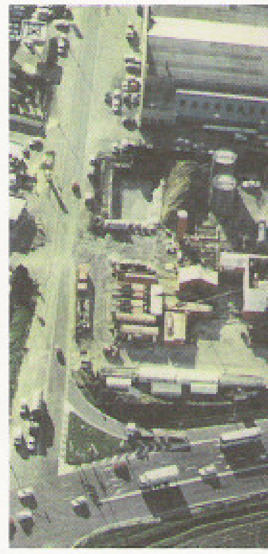
In the Paris Basin, for instance, absorption chillers can be placed in grid substations and the primary hot fluid supplied by the geothermal heat plant. The chilled water can be piped to consumers via the same flow circuit used for heating and the same heaters although, in this respect, alternative devices (fan coils, ceiling coolers) would be preferable. Note that each absorption chiller unit needs to be equipped with a cooling tower.

Costs

Geothermal undertakings at large, and GDH in particular, are capital intensive owing to the high infrastructure (mining – geothermal wells – and surface – piping) investments required. Those are, on the other hand, compensated by the low running – operation/maintenance – costs. Depending on local geothermal settings (high/low heat flows, shallow/deep seated sources), socio-economic conditions and pricing policies (kWht or m^3 of hot water) the average MWht selling price to GDH subscribers varies between 30 and 60 €/MWht.

Sustainability

Given economic (project life), reservoir longevity (cooling breakthrough time) and well physical lifetimes of say thirty years, the question often arises as whether there is a life after these critical thresholds and, if so, for how long. These issues have been thoroughly investigated, in particular in the Paris Basin, where GDH lives extending over 75 to 100 years, i.e. far beyond project life expectations, could be assessed provided the production/injection wells be periodically (every 25-30 years) (re)completed and drilled at adequate reservoir locations, according to corrosion resistant designs. Hence, the projected scenarios meet sustainability requirements.



Environmental impact

Close to zero atmospheric emissions of green house gases. Among the indirect non quantified benefits, known as externalities, of GDH ought to be mentioned the contribution to significant reduction of environmentally provoked diseases (asthma among others).

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