



***K4RES-H***

**KEY ISSUE 5 : INNOVATIVE APPLICATIONS  
GEOHERMAL UTILISATION FOR COOLING**

<b>Introduction</b>	2
<b>State of the art</b>	3
<b>Market potential</b>	6
<b>Barriers to growth</b>	8
<b>Recommendations</b>	9
<b>Reference to more detailed sources of information</b>	10

## INTRODUCTION

Over the last decades the cooling requirement of buildings steadily increased, due to internal heat sources, changes in architectural design, desire for enhanced comfort, etc. Space cooling of buildings is no longer restricted to the warmer, Southern regions.

Geothermal energy has been used for cooling since a long time, in the form of reversible geothermal heat pumps. Already some of the first installations in the late 1940s used this option, where the heat pump in summertime acts as a cooling machine and dumps heat into the geothermal system. The advantage here is a much higher cooling efficiency than using the warm ambient air as a heat sink. In the USA and Canada, this technology meanwhile is very popular under the name “geoexchange system” (e.g. the ranch in Crawford, Texas, owned by president Bush, is equipped with such a system).

In the mid 1980s, the idea of direct cooling was first described in Switzerland and tested in Germany. Here the cooler regions in the upper part of the earth’s crust (down to ca. 100 m) are used as a direct heat sink, together with fan coil units, cooling ceilings etc., accepting cooling temperatures of up to ca. 18 °C. This technology can not provide dehumidification of the cooled air and thus is either restricted to climates not too humid, or required additional dehumidification. Today, most of the geothermal heat pumps in commercial applications (offices, etc.) use one of these options, and an increasing number of installations in the residential sector, too.

A new use of cooling in combination with geothermal technology will be demonstrated in the Renewable Energy House in Brussels, where the borehole heat exchangers of a geothermal heat pump system act as a heat sink for re-cooling of the condenser of a solar absorption cooling system (fig. 1.)

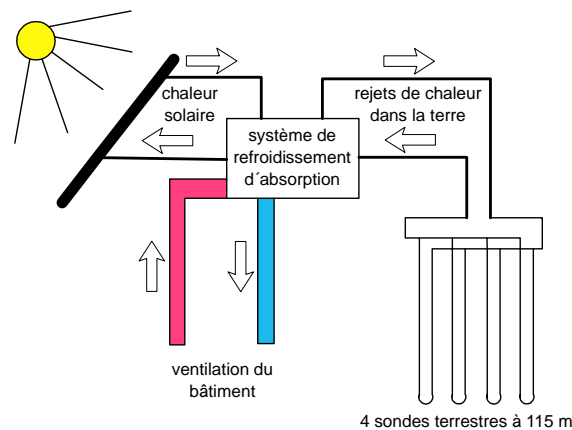


Fig. 1: Solar absorption cooling with geothermal re-cooling in REH, Brussels

A very good potential for larger systems (large individual building, district cooling) can be seen in geothermal absorption cooling. The geothermal heat here is the driving energy for an absorption chiller. The basic technology exists, however, the system concepts are still under some development, and demonstration plants are few (only one in Europe by now). With this innovative technology, a new market for geothermal applications could be opened, and the economy of existing deep geothermal heating systems could be improved by using the heat also in summertime.

## STATE OF THE ART

### Geothermal absorption cooling

Absorption cooling driven by hydrogeothermal energy can cover cooling loads; condenser re-cooling by air or UTES (fig. 2).

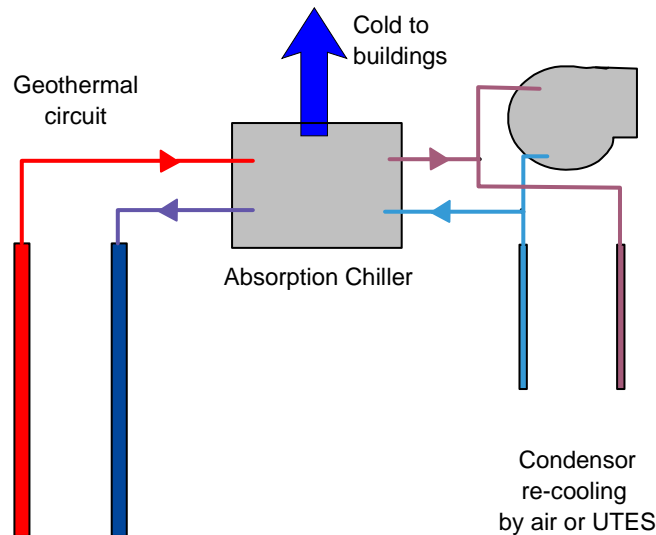


Fig. 2: Schematic of a simple geothermal absorption system

Absorption cooling machines (fig. 3) are frequently found in conventional district heating systems, using heat not needed in summertime to provide cooling. With network temperatures in excess of 90 °C this technology is available. Most absorption cooling machines (chillers) require about 90 °C and more as activation energy.

In most geothermal district heating systems the temperature levels are lower, in the 70-90 °C range. This is due to the prevailing temperatures in the geothermal aquifers used for this purpose in France, Germany, Poland, Hungary and others. So geothermal absorption cooling needs either high initial geothermal temperatures, or adapted systems running with lower temperature and having efficient re-cooling systems.

The absorption cycle is a process by which refrigeration effect is produced through the use of two fluids and some quantity of heat input, rather than electrical input as in the more familiar vapour compression cycle. Both vapour compression and absorption refrigeration cycles accomplish the removal of heat through the evaporation of a refrigerant at a low pressure and the rejection of heat through the condensation of the refrigerant at a higher pressure.

The method of creating the pressure difference and circulating the refrigerant is the primary difference between the two cycles. The vapor compression cycle employs a mechanical compressor to create the pressure differences necessary to circulate the refrigerant. In the absorption system, a secondary fluid or absorbent is used to circulate

the refrigerant. Because the temperature requirements for the cycle fall into the low-to-moderate temperature range, and there is significant potential for electrical energy savings, absorption would seem to be a good prospect for geothermal application.

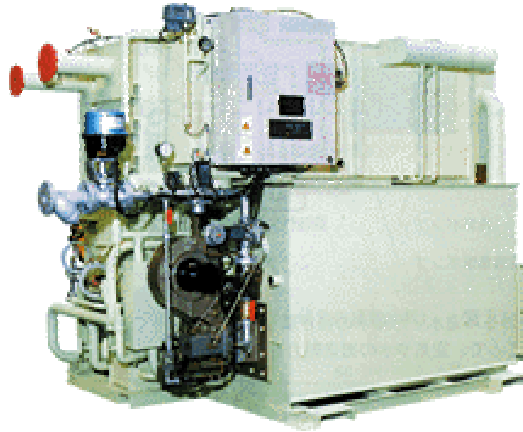


Fig. 2: Absorption chiller (example from Hitachi)

Absorption machines are commercially available today in two basic configurations. For applications above 15°C (primarily air conditioning), the cycle uses lithium bromide as the absorbent and water as the refrigerant. For applications below 15°C, an ammonia/water cycle is employed with ammonia as the refrigerant and water as the absorbent.

There are some design constraints for geothermal absorption cooling, so it is necessary to evaluate the following factors when considering such application for space conditioning :

**Resource temperature:** Substantial derating factors must be applied to equipment at temperatures less than 100°C. Very high resource temperatures or two-stage are required for low-temperature refrigeration.

**Absorption machine hot water requirements compared to space heating flow requirements:** Incremental well and pumping costs should be applied to the absorption machine.

**Refrigeration capacity required:** Larger machines have lower incremental capital costs on a €/kW basis. Coupled with the larger displaced energy, this result in a more positive economic picture.

**Annual cooling load for space conditioning, in full load hours or for process cooling, in terms of load factor:** Obviously higher utilisation of the equipment results in more rapid payback.

**Pumping power for geothermal resources with unusually low static water levels or drawdowns:** Pumping power may approach 50% of high efficiency electric chiller consumption.

A small-scale installation of this type has been integrated in the geothermal district heating in Zakopane (PL), supplying 45 kW of cold. The absorption chiller used here has been imported from India and was designed for ca. 100 °C activation heat, when it would

deliver ca. 110 kW of cooling capacity. In the Zakopane system, however, it only can be fed with water of about 80 °C, reducing the cooling capacity to some 45 kW. Re-cooling is done by a standard air cooler outside the administration building of the district heating company to which the cooling is connected.



**Figure 1.** Poland, 2004: geothermal plants in operation, under construction and spas using geothermal waters (division into geothermal provinces after Sokolowski, 1993).

Geothermal Energy Applications In Poland, 2004 – 2005\* Beata Kępińska

Further projects exist e.g. in Turkey, where plans are advanced for a large absorption cooling system for the Academic Hospital of Dokuz Eylül University in Izmir. Here the geothermal temperatures of the Balçova geothermal field in some places exceed 100 °C, and the Mediterranean Sea is close by to act for re-cooling.



## MARKET POTENTIAL

A good future development can be seen in the use of geothermal energy for cooling purposes, especially in the hotter regions of EU. Like low-temperature geothermal power production, geothermal absorption cooling is restricted to areas with geothermal resources of about 100 °C and above.

High enthalpy opportunities are limited to these regions:

- Within EU territory: Italy, Greece, French DOM-TOM (e.g. Guadeloupe), Spanish Canary islands and Portugal (Azores)
- Rest of Europe: Iceland and Turkey

The use of geothermal absorption cooling can be done in all basin areas with hydrogeothermal resources of sufficient temperature, as to be found in:

- the Alpine Molasse basins (both north and south of the Alps)
- the Pannonian basin (Hungary and parts of Slovakia, Slovenia, Serbia and Romania)
- to a lesser extend, in the basin area extending from the Paris basin (incl. Southern England) through Benelux, Northern Germany, Denmark and the southernmost tip of Sweden into Poland and Lithuania.

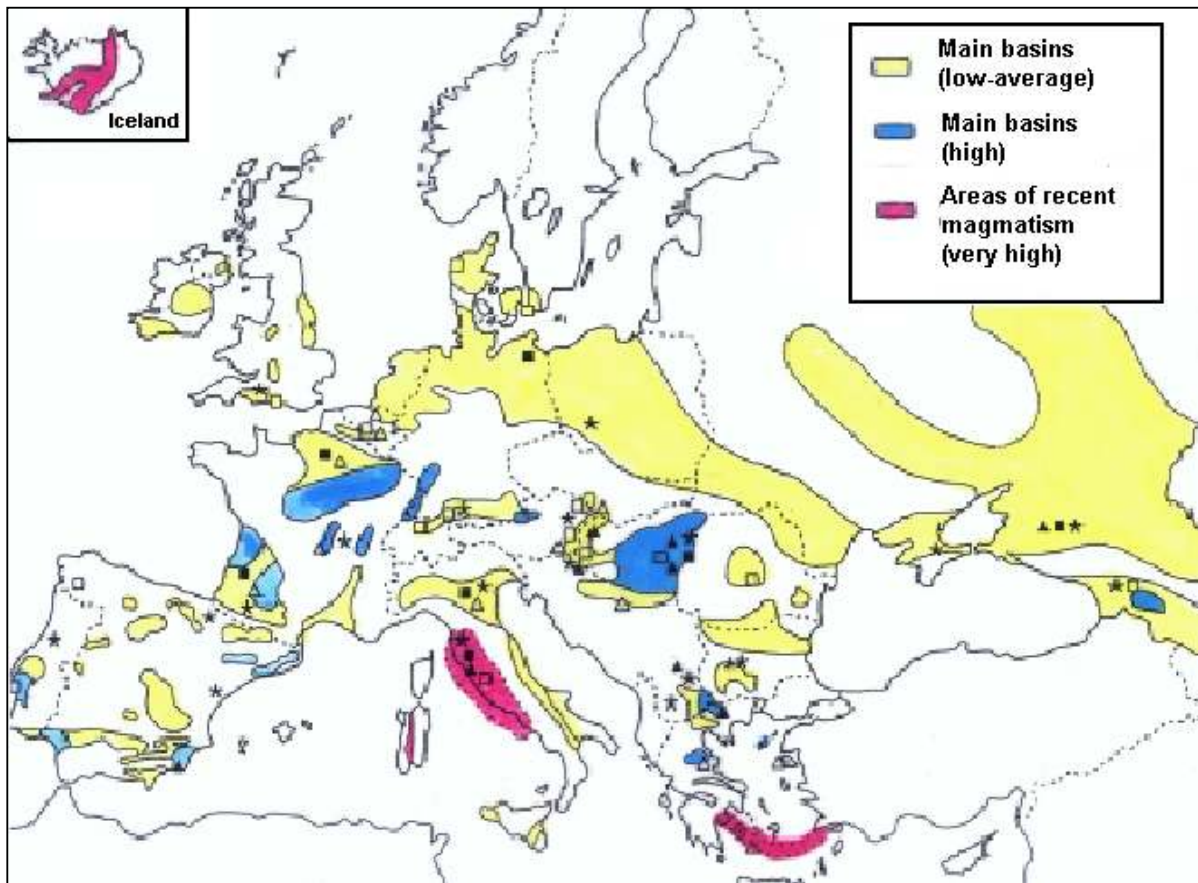
Another geological feature allowing for this kind of CHP-plants are graben systems

- the Upper Rhine Graben (with a lot of ongoing geothermal power activity in the German part of the graben)
- the Rhone and Limagne graben systems in France
- several smaller, but highly prospective systems in South-East Europe (Serbia, FYROM, Bulgaria, Greece).

In all of this applications with temperatures above 100 °C a conflict might arise with low-temperature geothermal power production, as the same amount of geothermal fluid can only be used for power or for cold at the same time. No conflicts will arise in geothermal fields of higher temperature, where the fluid temperature after the power conversion cycle still will be high enough for driving absorption chillers. Another option is to develop absorption chillers that still can provide high efficiency in the 70-80 °C range. This kind of machines also could be used very efficiently in cooling from solar heat or waste heat.

Compared to conventional cooling and even to cooling with reversible geothermal heat pumps, geothermal absorption cooling has tremendous ecological benefits. Only minor electric input is required for the cooling process itself (for the solvent circulation pump), as no compressors has to be operated. However, sites with high pumping requirement for the geothermal circuit should be avoided, as this will decrease the benefits. In general, geothermal absorption cooling has about the same ecological advantages as direct cooling from shallow geothermal plants. The technical advantage over this shallow technology is that with absorption cooling, dehumidification is possible and much higher loads can be covered.

An exceptionally good market potential can be seen in the touristic sector (air conditioning of hotels etc.) in the Mediterranean or on the Atlantic islands.



**Main basins and geothermal resources in Europe**

## BARRIERS TO GROWTH

The two main barriers can be named:

1. Technology of low-temperature absorption cooling
2. Knowledge, Experience, Demonstration

to 1.:

Technology exists, but is not yet adapted to the specific needs of the geothermal systems, i.e. activation temperatures of ca. 70-90 °C to avoid conflicts with geothermal power production in the >100 °C geothermal systems.

to 2.:

The knowledge of this kind of technology is almost non-existent within EU, and a number of demonstration plants and information activities would be required

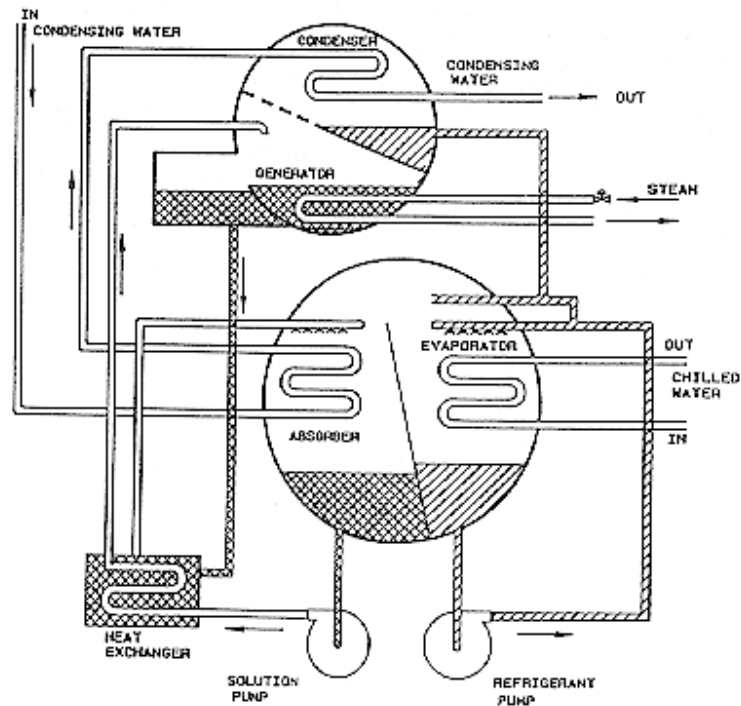


Figure Typical absorption chiller components.

## RECOMMENDATIONS

The two main barriers can be named:

1. Technology of low-temperature absorption cooling
2. Knowledge, Experience, Demonstration

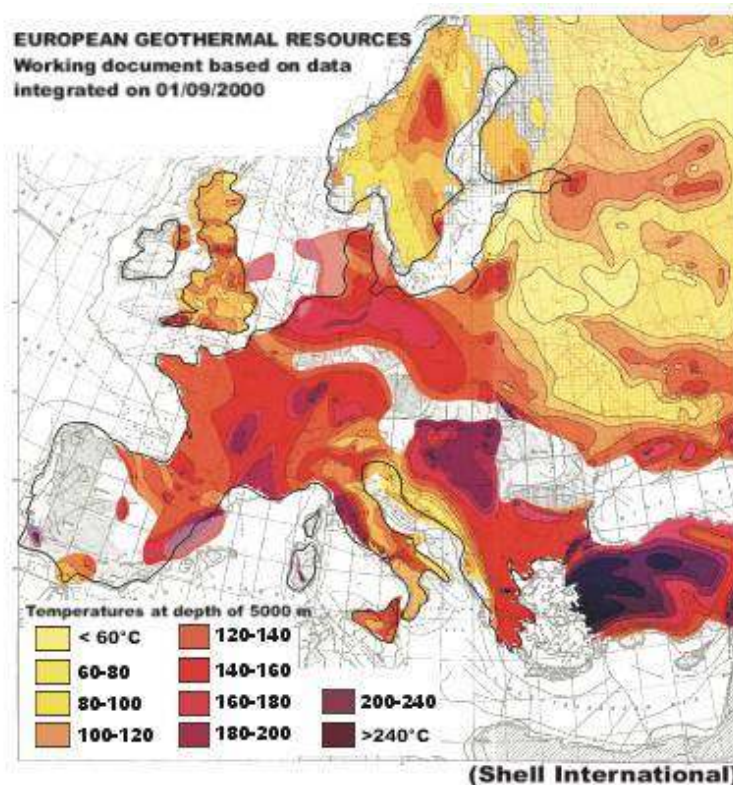
to 1.:

Further R&D is required both in the absorption chillers directly (varying of working fluid pairs, multi-stage cycles, etc.) and in the system concepts. The important parameter to achieve high efficiency is not only the absolute temperature of the activating heat, but more the temperature difference between activation and re-cooling. Hence more efficient re-cooling with lower temperatures can increase efficiency of the system even with moderate geothermal fluid temperatures. Options are shallow geothermal systems, aquifer cold storage systems (to avoid overheating of groundwater due to prolonged heat injection from cooling), or surface waters like the sea.

to 2.:

The acceptance of this technology only can be created by demonstrating it under different geothermal and climatic conditions, and by disseminating the results to the design engineers and the interested public. Support from EU for this task is badly needed.

### Potential after Shell-study :





## REFERENCE TO MORE DETAILED SOURCES OF INFORMATION

Sanner, B., Mands, E. & Sauer, M.K.: Larger geothermal heat pump plants in the central region of Germany. *Geothermics*, 32, 589-602, 2003

Spitler, J.D. and C. Underwood. 2003. UK Application of Direct Cooling Ground Source Heat Pump Systems. Proceedings of ASHRAE-CIBSE Conference, Edinburgh, Scotland, September 24-26, 2003.

### ABSORPTION REFRIGERATION

Kevin D. Rafferty, P.E.  
Geo-Heat Center. Klamath Falls, OR 97601

Geothermal Energy Applications In Poland, 2004 – 2005\* Beata Kępińska  
*IGA Newsletter January – February 2005*