Opinion of the European Economic and Social Committee on The use of geothermal energy

(2005/C 221/05)

On 1 July 2004, the European Economic and Social Committee, acting under Rule 29(2) of its Rules of Procedure, decided to draw up an opinion on the use of geothermal energy.

The Section for Transport, Energy, Infrastructure and the Information Society, which was responsible for preparing the Committee's work on the subject, adopted its opinion on 17 January 2005. The rapporteur was **Mr Wolf**.

At its 414th plenary session of 9 and 10 February 2005 (meeting of 9 February 2005), the Committee adopted the following opinion by 132 votes, with 2 abstentions:

This opinion supplements earlier Committee opinions on energy and research policy. It describes the development and use of geothermal energy, as an energy source which, given the extent of reserves, meets the criterion of sustainability, does not contribute to global warming through CO_2 emissions, and can therefore be considered as a renewable energy source. The opinion includes a brief overview and evaluation, set in the context of the global energy issue, of current development and use of geothermal energy, its potential, and the problems connected with launching it commercially.

Table of contents:

1. The energy issue

1.1 Usable energy [1] is the mainstay of our contemporary way of life and culture. Its ready availability opened the door to our present-day standard of living. Unprecedented strides have been made in the major and emerging industrialised countries in terms of life expectancy, food supply, overall prosperity and personal freedom. Insufficient energy supply would severely jeopardise these achievements.

1.2 The need for a secure, inexpensive, environmentally sound and sustainable supply of usable energy is at the heart of the Lisbon, Gothenburg and Barcelona European Council decisions. EU energy policy is thus pursuing three closely related and equally important objectives, namely to safeguard and enhance (1) competitiveness, (2) security of supply and (3) the environment — all of them linked by the common thread of sustainable development.

1.3 In several opinions [2], the Committee has noted that supplying and using energy puts a strain on the environment, presents risks, depletes resources and involves the problem of external dependence and imponderables, as in the case of current crude oil prices. The Committee has also pointed out that the most important measure for reducing the risks associated with the security of energy supply, economic crises, and other risks is to ensure the most diverse and balanced possible use of all types and forms of energy, including all efforts to conserve energy and use it rationally.

1.4 In technical terms, however, none of the potential future energy supply options and technologies is perfect. None is wholly free of damaging environmental impacts. None is sufficient to cover all needs, and it is difficult to adequately gauge their long-term potential. Moreover, current trends and the rising costs of both conventional and alternative energy sources clearly indicate that future energy supply costs are unlikely to be as advantageous as current costs of using fossil fuels [3], such as crude oil, coal, and natural gas.

[1] Energy is not actually consumed, but merely converted and, in the process, used. This happens through conversion processes such as coal combustion, the conversion of wind energy into electricity, and nuclear fission (conservation of energy; E = mc2). However, the terms 'energy supply', 'energy production' and 'energy consumption' are also used.

[2] *Promoting renewable energy: Means of action and financing instruments; Proposal for a Directive of the European Parliament and of the Council on the promotion of cogeneration based on a useful heat demand in the internal energy market; Draft proposal for a Council Directive (Euratom) setting out basic obligations and general principles on the safety of nuclear installations and Draft proposal for a Council Directive (Euratom) on the management of spent nuclear fuel and radioactive waste; The issues involved in using nuclear power in electricity generation; Fusion energy.*

[3] Future use of which will have to be increasingly restricted in view of both the limited reserves of such fuels and also the need to reduce CO_2 emissions (Kyoto Protocol).

1.5 Nor, therefore, can a forward-looking, responsible European energy policy bank on being able to secure an adequate energy supply along the lines of the objectives set out above by using only a small number of energy sources.

1.6 Thus, no secure, long-term, environmentally sound and economically viable energy supply exists — either in Europe or elsewhere in the world ([1]). The key to potential solutions can lie only in further intensive research and development, which should include setting up pilot plants and evaluating them from both a technical and an economic perspective, gradually working towards commercial launches of new energy sources.

1.7 The Committee has also made the point that, given the slow pace of change in the energy industry, the fact that climate (greenhouse) gas emissions are a global, not a regional issue, and the expectation that the problem will further worsen, particularly in the second half of the century, the approach to the energy issue should be more global in scale and cover a substantially longer time period.

1.8 The problems of finite resources and emissions are compounded by the forecast two- or even three-fold increase in global energy requirements by 2060 as a result of population growth and the need for less developed countries to catch up. On the basis of current knowledge, increased efficiency and energy savings alone will not be enough to offset these very substantial additional requirements.

1.9 Any strategy ([2]) and prospects for development must therefore look beyond the timeframe of 2060.

1.10 As the Committee has also noted, public perceptions and open debate in this area reflect a broad range of opinions that veer between over- and underestimating the risks and opportunities involved.

1.11 There is therefore still no sufficiently consistent global energy policy. An additional problem is the fact that the EU needs to compete on a level playing field in the global economy.

([1]) The overall problem has been foreshadowed by previous oil crises (e.g. in 1973 and 1979), current increases in oil prices, and the current controversy – centred on the trade-off between economy and environment – about the allocation of emissions certificates.

([2]) However, see 2.2.1.2 and 2.2.2.2.

1.12 Even within the EU Member States, there are considerable differences of approach to the energy issue. However, both at national and European levels, there is broad consensus as to the need to continue developing all possible energy sources (with the exception, in some Member States, of nuclear energy). To this end, numerous R&D programmes and other support programmes, some of which are funded from multiple sources, have been launched both by individual Member States and at European level.

1.13 One of the EU's main objectives in this field is to achieve a significant medium- to long-term increase in the use of renewable energy sources, which can also help protect the climate. In this context, geothermal energy can make a significant contribution.

2. **Geothermal energy**

2.1 Technologies for tapping into and using thermal energy flows from the earth's interior, which is very hot, to the surface, are referred to as geothermal energy production. Water (in liquid form or as steam) is used as the heat carrier.

2.1.1 However, the density of such thermal energy flows is very low, and temperatures rise only slowly as distance below the earth's surface increases, at an average rate of around 3°C per 100 m. Geological zones in which the temperature gradient is steeper are referred to as geothermal anomalies.

2.1.2 The heat balance of geological layers close to the earth's surface can also be affected by solar radiation; however, in the following paragraphs this energy is included in the category of geothermal energy.

2.2 There are **two options** for using geothermal energy.

2.2.1 The **first** of these is using **geothermal energy for heating purposes**. Currently, about 40 % of the total energy supply in the EU is used for heating purposes; this generally requires relatively low (water) temperatures (e.g. as low as < 100° C).

2.2.1.1 For heating purposes alone, so-called **geothermal probes** are used among other things. (These involve a coaxial tube, the lower end of which is sealed, and through which water flows down to a depth of 2.5-3 km, then up and out again, thereby absorbing useable heat of up to approximately 500 kWth.

2.2.1.2 One option for tapping energy very close to the earth's surface is to use **geothermal pumps** ('reverse cycle chillers') to heat buildings (from around 2 kWth to 2 MWth); these also require a refrigerant ([1]). There are several types, tapping energy from depths of as little as 1 metre up to several hundred metres, depending on which technology is used.

2.2.2 The **second option** is to **generate electrical energy**. This requires higher (water) temperatures (e.g. > 120° C): usually, there are two boreholes, some distance apart; the water to be heated is fed underground through one borehole and flows out from the other. A greater amount of heat — 5 to 30 MWth — can be achieved in this way.

2.2.2.1 However, even these (water) temperatures are still insufficient to achieve the requisite thermodynamic efficiency (to transform heat energy to electricity), and in view of the temperatures required to reach boiling point within the turbine circuit.

2.2.2.2 For this reason, substances with a lower boiling point than water such as perfluorpentane (C_5F_{12}) are used for preference as the working fluid in turbine circuits. Special turbine circuits such as the Organic Rankine Cycle (ORC process) or the Kalina process are being developed for that purpose.

2.2.3 One particularly advantageous arrangement is to **combine both applications** (heat and electricity) and to use the residual heat arising during or in connection with electricity generation for heating purposes, thus providing heat and power at the same time.

2.3 However, in order to supply energy which is technically useable for electricity generation in particular, geothermal reservoirs have to be located sufficiently deep, usually several kilometres below the earth's surface, requiring costly deep drilling.

2.3.1 At the same time, the costs of tapping and using such reservoirs increase significantly with depth, and therefore, depending on how the energy is to be used, a balance must be struck between bore depth, efficiency and heat output.

2.4 For this reason, earlier stages of the search for useable heat reservoirs concentrated on geological areas with geothermal anomalies.

2.4.1 High geothermal gradient anomalies (so-called high-enthalpy ([2]) reservoirs) are mostly located in areas of intensive volcanic activity (Iceland, Italy, Greece, Turkey). The therapeutic properties of thermal water heated by high-enthalpy reservoirs have been known since ancient times, and they were first used to generate electricity about one hundred years ago (Larderello, Italy, 1904).

2.4.2 By contrast, low geothermal gradient anomalies (so-called low-enthalpy reservoirs), i.e. areas in which the temperature gradient is only slightly higher than usual, are located in areas of intensive tectonic activity (Rhine Graben, Tirennian Sea, Aegean Sea, etc.), and more generally in sedimentary aquifers (Pannonian Basin in Hungary and Romania, North German — Polish Basin).

2.5 Due to the limited number of areas with geothermal anomalies, since the mid-1980s efforts have increasingly concentrated on tapping the heat stored in 'normal' geological formations, in order to cope with the rising demand for energy and to be able to match the supply of heat or power more closely to demand in the surrounding areas.

2.5.1 As a result, geothermal reservoirs in areas without geothermal anomalies began being used for energy production in the 1990s, mainly in German-speaking countries. Electricity generation only began in Altheim and Bad Blumau (Austria) and in Neustadt-Glewe (Germany) during the last 4 years.

2.5.2 As this takes place at depths of at least 2½ km, but preferably 4-5 km or more, deep drilling is necessary.

([1]) In future e.g. CO_2 could be used.

([2]) Enthalpy, which is a term used in thermodynamics, is useable energy content (internal energy plus expansion energy).

2.6 Technologies for producing geothermal energy have the following advantages:

— unlike wind or solar energy, geothermal energy does not depend on the weather, time of day, or season, enabling it to contribute to all-important baseload capacity;

— pre-existing heat only needs to be brought from the reservoir at a depth of several kilometres to the surface, eliminating the processes involved in primary heat production (such as combustion or nuclear processes) and the concomitant economic and environmental costs involved;

— thermal reservoirs are an almost inexhaustible and renewable source of heat, which could in theory make a substantial contribution to energy production.

2.7 However, they also have the following disadvantages:

— the temperatures are too low to achieve a satisfactory level of thermodynamic efficiency for electricity generation;

— to ensure that heat exchange takes place and that the reheating capacity of the underground reservoir is not exceeded, very large volumes need to be tapped and used so that, at high heat extraction rates, the reservoir does not display signs of exhaustion that could force it to be abandoned earlier than planned;

— when reservoirs are used, it is essential to prevent any potential impact from or release of environmentally harmful and/or corrosive substances (such as CO_2, CH_4, H_2S and salts) and to keep equipment corrosion in check;

— the costs and economic imponderables (such as prospecting risks and the possibility of exhaustion) associated with tapping and using geothermal reservoirs are still relatively high.

3. **Current situation**

3.1 Basically, there are three technologies, with variations, for tapping and using deep geothermal energy; these usually require at least two boreholes (a doublette) [1]:

— hydrothermal reservoirs are used as a source of underground, non-artesian (i.e. not pressurised) water, which is brought to the surface, and up till now has generally been used for heating. At present, this technique is being extended to electricity generation using water at higher temperatures. The medium for heat transfer is the underground water from the reservoir;

— the hot dry rock (HDR) process involves deep boreholes being sunk into suitable geological formations and extensive stimulation. Surface water is injected underground and used to extract stored heat by cooling the heat exchange surfaces, which are artificially created by stimulation of deep layers of rock;

— pressurised hot water reservoirs, with a water/steam mixture at temperatures of up to 250°C or more (however, such high temperatures are of rare occurrence) which can be used to generate electricity or for heating.

In addition, ground-level technologies [2] are being developed to improve heat exchange and efficiency.

3.2 In the EU, geothermal capacity for generating electricity, most of which is located in Italy, and which generally uses geothermal anomalies, is currently about 1 GWel, or about 2 % of total EU electricity generating capacity. Geothermal capacity for direct heating is about 4 GWth, but is forecast to rise to 8 GWth or more by 2010.

3.3 Therefore, neither form of geothermal energy use has yet made a substantial contribution to EU energy supply, and they represent a negligible proportion even of renewable energy use.

3.4 However, thanks to support from both Member States and the EU, use of geothermal energy has increased substantially over the last few years. Provided the heat output ranges from just a few to several tens of MWth geothermal energy still makes a contribution to decentralised energy supply.

3.5 In the view of the Committee, this development is positive and well worth supporting. In many such cases, pilot plants are needed in which various methods can be tested and developed.

3.6 Comparing the costs per 1 KWel of electricity generated from various renewable sources, geothermal energy (even if heat and power generation can be combined) currently costs about twice as much to use as wind energy, and half as much as solar energy.

(1) However, see 2.2.1.1 on sealed geothermal probes and 2.2.1.2 on geothermal heat pumps.

(2) See 2.2.2.2 on turbine circuits.

3.6.1 However (see above) geothermal energy supplies can be largely matched to demand. This advantage will become increasingly significant as renewable energy takes a larger share of the energy market: using the fluctuating output from wind and solar energy will increasingly require technologies for buffering and regulating energy, and it is likely that energy-consuming and costly storage media such as hydrogen will be needed.

4. **Future development and recommendations**

4.1 Provided that it is no longer restricted to geothermically anomalous areas (see also points 2.4 and 2.5), geothermal energy has the potential to make a significant contribution to environmentally sound and sustainable energy supplies (see also point 4.13).

4.2 In order to use and develop this potential for economically viable electricity generation, boreholes need to be sunk to a depth of at least 4 or 5 km, to reach rock layers in which temperatures are at the threshold of about 150° C. In addition, rock at this level needs to be treated (stimulated) so as to enable a sufficient quantity of water to circulate and sufficient heat exchange to take place between the hot rock and the water which is naturally present or pumped through.

4.2.1 However (see also point 2.2.1.1), lesser bore depths of e.g. 2-3 km are sufficient if the energy is to be used solely for heating purposes.

4.3 Appropriate technological solutions are already being developed and tested at several locations in Europe (e.g. Soultz-sous-Forêts, Gross Schönebeck) with varying geological formations. The development of geothermal technologies which are as independent as possible of location and are therefore suitable for export offers the main scope for progress, but this still requires considerable R&D work.

4.4 On the one hand, development of the various technologies which already exist in a rudimentary form needs to continue in order to make them viable, at the same time as checking compliance with the previously mentioned criteria for sustainable use of geothermal energy.

4.4.1 One particularly important question is whether the hydraulic and thermodynamic criteria for adequate sustainability of a stimulated reservoir can actually be met.

4.5 On the other hand, the individual stages of the process need to be gradually improved and made more efficient in order to bring costs down to a competitive level (see below). At the same time, research and development (see point 1.6), as well as work on preparing the market are needed, in order to bring down production-related costs.

4.6 In the medium term, making geothermal energy competitive means enabling it to compete with wind energy in terms of costs. There is a high probability of this happening, given that the disadvantages of wind energy are becoming increasingly apparent: wide fluctuations in output result in major additional costs and emissions from other sources, wind farms can be unsightly, and the noise can disturb people living in the vicinity; in addition, they increasingly require repair and maintenance. The costs borne by consumers or the public purse must also be included in any overall assessment.

4.7 In the long term, given that prices of crude oil and natural gas are likely to continue rising, and reserves may possibly begin running out, general competitiveness will become an issue for geothermal energy. The question to be answered is when, if ever — taking into account external costs of all energy production technologies — geothermal energy will achieve long-term competitiveness, without any form of subsidy or market-distorting preferential treatment.

4.8 In the meantime, the following measures are needed [1]:

— effective R&D programmes at national and European levels to bring scientific and technological development in the field to the point where technologies and individual stages of the various processes can be developed and tested at an adequate number of test sites,

— legislation to promote private investment (e.g. laws on the sale of electricity to the grid, heating and air-conditioning systems) designed to provide initial, tapered support for commercial launches so as to make energy sales during the launch stage attractive for a limited period, not least in order to test, enhance and evaluate economic potential. In particular, this also applies to contractual arrangements between energy supply companies and consumers,

— action to offset the risks associated with prospecting and tapping geothermal reservoirs, e.g. in sinking boreholes and locating viable sources.

4.9 The Committee is pleased to note that considerable progress has already been made in this field. It fully endorses the Commission's existing and planned R&D projects, and also its intention to again substantially increase its activity in this area in its next R&D framework programme. It also endorses the relevant R&D programmes of Member States and their efforts, by adopting appropriate support measures, to facilitate and encourage the commercial launch of geothermal energy on a trial basis.

(1) See: *Promoting renewable energy: Means of action and financing instruments*

4.10 In this connection, the Committee reiterates its earlier recommendation that the opportunities offered by the European Research Area should be utilised through a comprehensive, transparent and coordinated energy research strategy, supported by all the players involved. This strategy should be made a key element of the seventh R&D framework programme and the Euratom programme.

4.11 This strategy should give appropriate emphasis to the R&D measures which are required to develop geothermal energy, until it becomes possible, in the context of a changing energy market, to provide a more accurate estimate and evaluation of the long-term costs and the achievable potential of such technology.

4.12 The Committee also recommends that all geothermal energy R&D programmes, i.e. including those which until now have been solely supported at a national level, be integrated as far as possible into a European energy research programme, to operate on the basis of open coordination. This would have the benefit of promoting European cooperation in the field.

4.13 In this context, the Committee sees the participation of new Member States in the EU R&D framework programme as an opportunity. Demonstration plants and pilot plants should be set up in these countries also, in the course of the forthcoming renewal of their existing energy systems.

4.14 In addition, the Committee recommends that the Commission sufficiently harmonise the effective measures taken within the EU to promote commercial launches (e.g. legislation on the sale of electricity to the grid) to enable EU-wide competition, at least in regard to actual geothermal technology, to take place on a level playing field.

4.15 Given that geothermal energy lends itself particularly well to combined heat and power generation, the Committee also recommends that the Commission look into suitable heating networks and use of geothermal heat.

5. **Summary**

5.1 Technologies for tapping into thermal energy flows from the earth's interior, which is very hot, to the surface, are referred to as geothermal energy production.

5.2 This energy is mainly used for heating purposes, but it can also be used to generate electricity, or combined heat and electricity.

5.3 Geothermal energy is already being used in areas with geothermal anomalies, but it still represents an insignificant proportion of overall energy supply.

5.4 Technologies which allow areas without geothermal anomalies to be tapped offer the potential for geothermal energy to make a significant contribution to sustainable energy supply, and to base-load supply in particular. However, they require boreholes to be sunk to depths of about 4–5 kilometres, together with additional 'stimulation'.

5.5 However, there is also considerable potential for development in the use of heat pumps to tap geothermal energy close to the surface for the purposes of heating and air-conditioning.

5.6 The potential to contribute to baseload capacity distinguishes geothermal energy from sources with fluctuating output (e.g. wind and solar energy), which are becoming increasingly dependent on technologies for regulating, buffering and storing energy and which are meeting public opposition due to the amount of land they require and their aesthetic impact on the countryside.

5.7 The Committee reiterates its recommendation that the opportunities offered by the European Research Area be utilised through a comprehensive energy research strategy.

5.8 This strategy should include R&D measures which are needed to develop geothermal energy, continuing and, as appropriate, building on existing programmes.

5.9 The Committee recommends that all geothermal energy R&D programmes, which until now have been solely supported at a national level, be integrated into such a European energy research programme and the measures which it comprises, to operate on the basis of open coordination.

5.10 The Committee recommends initial, tapered incentives and legislation in all Member States (e.g. a law on the sale of electricity to the grid) for commercial launches and private investment, in order to make the production and sale of temporarily subsidised energy more attractive and thus also to help test, enhance and evaluate the economic potential of this energy form.

5.11 The Committee recommends that such support measures should be sufficiently harmonised within the EU to ensure that EU-wide competition in regard to geothermal technology takes place on a level playing field.

Brussels, 9 February 2005

The President
of the European Economic and Social Committee
Anne-Marie SIGMUND