# Executive Summary

Geothermal energy is one of the indigenous and environmentally friendly energy resources in use which the European Union intends to expand in order to reach its established goals for RE contribution to gross energy consumption in Europe, from the present 6% to 12% by the year 2010.

A key aim of the Blue book is to identify a series of measures which could effectively promote the use of geothermal energy in the EU, EEA countries and Switzerland, as well as countries that are likely to become associated with the EU in the near future (Agenda 2000 countries).

This study describes the present world-wide status of geothermal development, and the availability of geothermal resources. The advantages and benefits that make geothermal energy competitive, environmentally beneficial, reliable and safe compared to most other energy sources are also presented.

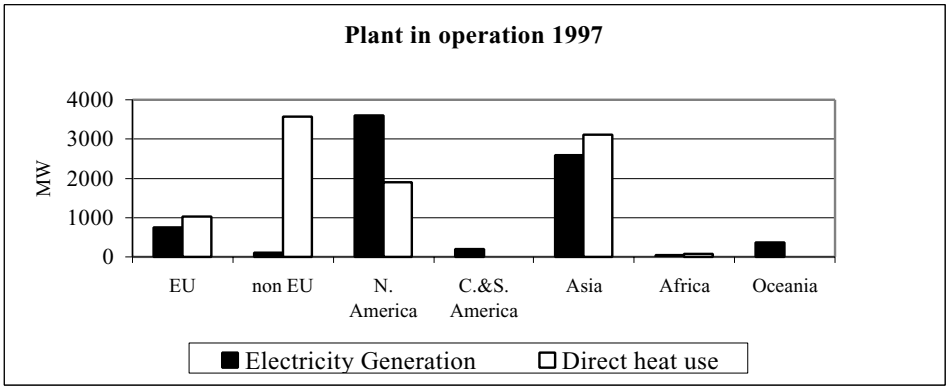
A detailed analysis of the global market conditions is also presented with short term opportunities and medium term development prospects by 2010. Furthermore, the Blue Book identifies a series of actions to develop the geothermal sector in the EU, particularly measures to increase the presence of European operators in the domestic and world geothermal markets.

## GEOTHERMAL RESOURCES

Geothermal resources are suitable for many different types of uses but are commonly divided into two categories, high and low enthalpy and according to their energy content. High enthalpy resources (>150 °C) are suitable for electrical generation with conventional cycles, low enthalpy resources (<150 °C) are employed for direct heat uses and electricity generation using a binary fluids cycle.

In recent years, significant advances have been made in use of ground source (geothermal) heat pumps for extracting energy from very low temperature resources (<20°C) for both heating and cooling. Other applications also use the seasonal energy storage in shallow formations (>200 m) which make use of the energy storage capacities of the rocks. These relatively recent uses have multiplied the number of countries and regions that can harness geothermal energy.

The present installed capacity and energy production from geothermal resources for electricity generation and direct heat use in the world is summarised in the figures below.




Electricity is presently produced from geothermal produced steam in 21 countries all over the world. Geothermal electricity generation in Europe is about 4,300 GWh/y, concentrated almost exclusively in three countries: Italy, Iceland and Turkey. The generation of the same amount of electricity from an average coal-fired plant would displace the emission to the atmosphere of 5 million tons of carbon dioxide, 46 thousand tons of sulphur dioxide, 18 thousand tons of nitrogen oxides, and 25 thousand tons of particulate matter every year.

All European countries exploit about 18,000 GWh/y of geothermal energy for direct heat uses such as space heating, greenhouses, balneology and processing industries representing about 52% of world production. EU countries represent only 11% of this total, whereas Iceland alone uses 17% of the total. Almost all fifteen EU countries have direct heat uses (most commonly for spas and bathing) while large space heating is mainly used in France, Germany and Italy.

## COMPETITIVENESS OF GEOTHERMAL ENERGY

Geothermal energy has been produced commercially on the scale of hundreds of MW for over three decades both for electricity generation and direct utilisation in many parts of the world. Geothermal energy has a number of positive features which make it competitive with conventional energy sources and some reneweables sources. These features include:

- it is a local energy source that can reduce demand for imported fossil fuels,
- it has a large positive impact on the environment by displacing combustion of fossil fuels,
- it is efficient and competitive with conventional sources of energy,
- geothermal plants can operate continuously, without constraints imposed by weather conditions, unlike other renewable sources,
- it has an inherent storage capability and is best suited to base-load demand,
- it is a reliable and safe energy source which does not require storage or transportation of fuels.

Moreover, pronouncements from the recent global conference held at Kyoto on climate change and EU strategies on environment control, recently declared in the White Paper from the Commission, include targets for the greater use of renewable sources of energy. A greater use of geothermal energy will have a large net positive impact on the reduction of carbon dioxide and other pollutants which clearly fits this strategy.

The more recent generation of geothermal power plants, emits on average only 136g/kWh of carbon dioxide per kilowatt-hour of electricity generated compared to the 453g/kWh of carbon dioxide for a power plant fuelled by natural gas or 1,042 g/kWh of carbon dioxide for a coal fired power plant.

At present the renewable energy sources with the greatest potential and the lowest emissions in Europe, in the short to medium term, are hydropower and geothermal energy. In this respect, it should be noted that the capacity factors for hydro and geothermal in Europe is now more than 70%, whereas 20-35% are typical values for solar and wind.

The availability factor of geothermal energy, expressed as the percentage of time the rated energy may be produced, depends mainly on the nature of the resource and secondarily on the availability of the equipment. Experience shows that this availability is often over 90% for geothermoelectric power plants and even higher for direct use plants. Under these circumstances the plant factor expressed (as the percentage of time the plant actually produces energy) is almost equal to the availability factor. For direct use, the plant factor is practically coincident with demand. Such factors are higher than those for fossil fuel plants and far higher than other renewables.

Taking the above factors into consideration only an increase in the use of biomass, hydro and geothermal energy can realistically influence the level of greenhouse gas emissions in Europe over the next 5-10 years for total energy use. These technologies can displace considerably more greenhouse gas emissions than any contribution from the foreseeable increase in utilisation levels from other renewables. Wind energy could make a significant contribution by 2005 and is growing rapidly.

Both high and low enthalpy geothermal power plants, can be implemented in modular units. This approach reduces the initial capital outlay and spreads investment, it also enables the availability of the resource to be evaluated before full-scale operation commences and allows revenue generation at the earliest possible opportunity, thereby improving the overall scheme financial performance and reducing exposure to geological or mining risk.

This study includes an example of a typical cost breakdown for a field and plant investment based on a reference 55 MW geothermal power plant and then proceeds to examine factors which can affect its economic performance. This reference or base case is used purely as an illustrative example.

Costs, and therefore the economic viability of geothermal energy schemes, are in reality strictly dependent on site-specific conditions and the type of application. It should be emphasised that the electricity generation cost is most sensitive to the specific cost of drilling wells and individual well productivity which varies considerably between different countries.

The great variability of technical and economic parameters involved in the implementation of geothermal projects (the specific field cost plus the plant cost) means that each geothermal project will invariably have a unique production cost and no broad generalisation is possible.

In the case of direct heat uses the investment cost and heat production cost vary considerably and reflect regional factors evident in different countries, and different types of application. The main factors which influence the production cost are the characteristics of the resources (depth, temperature, flowrate etc.), local climatic conditions, local heat demand and the pattern of heat consumption (large district heating systems, individual heating or cooling, geothermal heat pumps, others uses, etc.).

The overall competitiveness of geothermal energy is also determined by comparison with both conventional and other renewable energy sources. Usually the cost of energy is based upon standard economic and financial analyses. The funding of geothermal projects by the main international financing agencies are currently based on strict application of a least-cost analysis as part of their procedure for granting loans for energy projects.

It should be stressed that at present in Europe, the low cost of fossil fuels, especially natural gas, makes only the best geothermal resources competitive from a strict financial comparison.

Nevertheless, geothermal energy could become more competitive compared with conventional sources of energy if the comparison is not limited exclusively to strict financial criteria, but also takes account of other factors such as shadow costs and their economic consequences (the so-called "externalities").

The related *external costs* of conventional generation, (which in the case of geothermal resources is similar to other renewable sources) become **external benefits,** and are a parameter that substantially changes the level of the competitiveness in favour of geothermal energy. These external benefits can be quantified in monetary terms and should be an acknowledged factor for comparative purposes.

If externalities are included among the investment parameters, the full social and economic benefits can be realised, however, this may require public incentives to ensure successful investment in geothermal energy is possible. The acquaintance to the investor of this "added value" should not be regarded as a subsidy but looked on as a realignment of the economic benefits which arise from the project.

The external cost of traditional fuels has been estimated to be almost 10 times higher than the corresponding cost of renewables and almost 50% of the overall economic cost (against 1% for the renewable sources case).

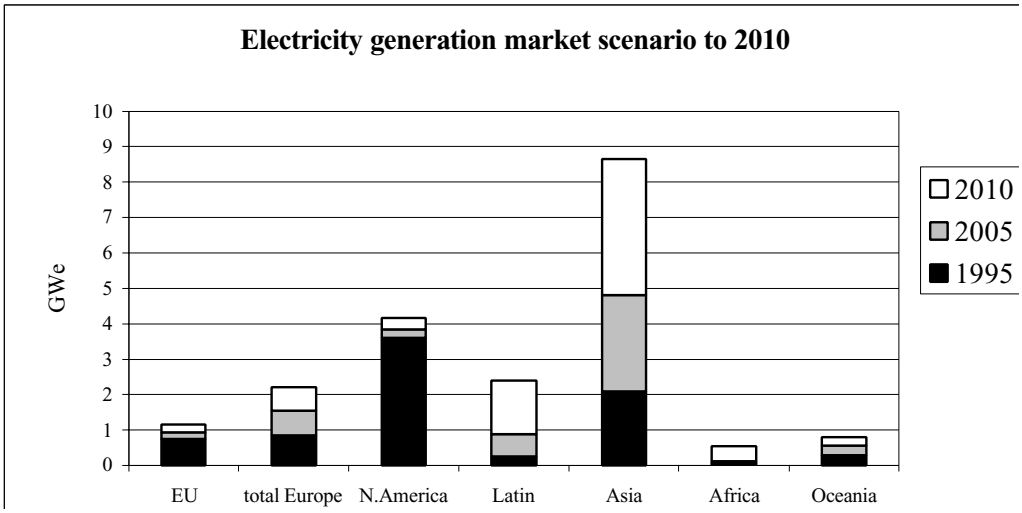
The quantification of externalities is a crucial aspect if geothermal energy is to be fairly evaluated, and also avoids penalising projects evaluated purely on the basis of a cash flow analysis.

## MARKET SITUATION AND PERSPECTIVES

The Blue Book has identified a series of measures that could be used to expand the exploitation of geothermal resources in Member States and increase the presence of European operators in the world geothermal market. This market is rapidly expanding, and European operators risk loosing their traditional dominance in the sector. This is due at least in part to the aggressive policy of the non-European industry which now provides a wide range of geothermal products and services, and a weak industrial/political lobby in Europe which favours decentralised geothermal interests founded in national bodies.

An average scenario up to the year 2010 for the **world electricity generation market** is shown in the below figure.

The greatest expansion in electricity generation in Europe is predicted for Iceland, Russia, Italy and Turkey.




The largest expanding markets are currently in South East Asia and Central-South America where market conditions differ. In the first region two main producers (Indonesia and the Philippines) have the same type of free market conditions while in Latin America a transition from state run monopolies to a concession system is currently in progress.

Private operators (mainly from the USA) are gradually dominating the South East Asian markets for electricity production from geothermal energy and their presence appears to be overwhelming the European competitors.

The Latin American market still seems partially open to penetration from European operators, which is generally positively received by local authorities on the continent. Efforts should be made to steer the European industry in this direction because non-European operators are presently moving to consolidate their presence in the Central and South American markets.

American and Japanese operators represent serious competition for the European geothermal industry which has not been able to meet the strategic and financial risks that are now dominating free-market economies which have been progressively imposed on the world market for electricity production including geothermal energy.

As a consequence European operators risk being push progressively to the fringe of the geothermal world market for electricity production and related businesses, or only sustaining a presence as subcontractors of services and components. The dominance and management, as well as most of the profits from projects, will consequently remain outside the European industry.

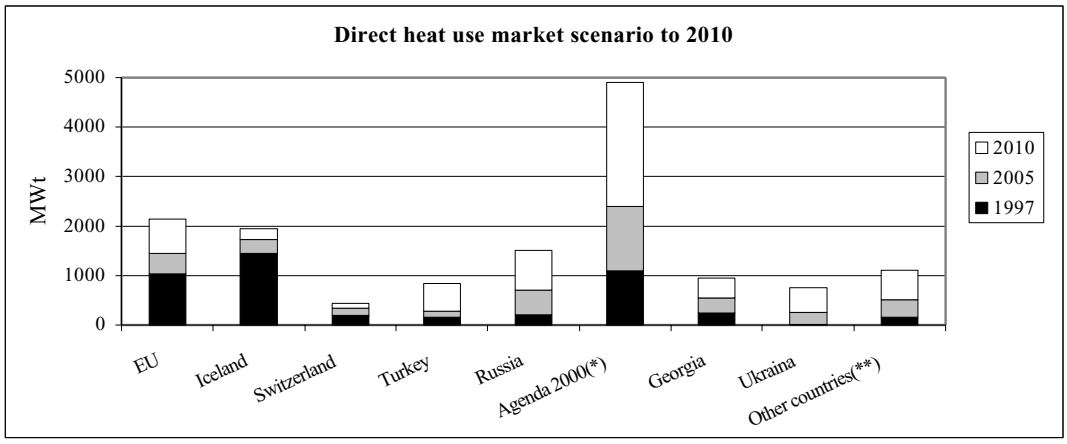
In contrast, **the market for direct uses** of geothermal energy has extensive potential in European countries where there are large resources to be exploited and a long tradition of using geothermal heat use. Opportunities both to extend this usage and to develop related businesses exist, especially in Eastern European countries and CIS countries, where large centralised district heating systems already exist which mainly use conventional fuels.

The market for direct use applications only exists when both resource and demand are coincident. This is why geothermal resources are only used where there is a large local energy demand. It is conceivable that new direct heat markets could be opened up where geothermal resources exist for example, horticulture, tourism and industrial processing.

Carbon dioxide emission reduction and energy saving aspects are becoming increasingly important in developed countries, and direct utilisation of geothermal resources could make a large contribution to this objective.

A minimum case scenario of the market for direct heat uses to the year 2010 in the EU and some others European countries, is shown in the figure below.

This scenario is expected to grow considerably if the development of geothermal heat pumps in many European countries will be implemented. Referring to the rest of the world, the market for the direct heat uses is quite unforeseeable and its development is generally subordinate to the implementation of national policies devoted to the reduction of pollutants emission.




(*) Bulgaria, Hungary, Poland, Romania, Slovakia, Slovenia
(**) Macedonia and Yugoslavia

## ACTIONS IN FAVOUR OF THE GEOTHERMAL ENERGY

The EU action plan should have two goals:

- to increase the exploitation of geothermal energy in the EU and associated countries;
- to support European firms within the sector to increase their share of the world market

Support for the spread of exploitation and use of geothermal energy will be directed mainly within the EU and associated countries, while support to EU operators will be directed at all other countries.

The recent White Paper "Energy for the Future: Renewable Sources of Energy" describes the EU strategy and objectives, but suggests that each Member State should decide its own strategy according to its own potential and resources.

This implies that an effective action plan will be outlined and decided at Member State level. The EU would be responsible for the guidelines and pressing Member States and Local Authorities to drive the implementation of new geothermal initiatives and in some cases to implement direct actions in favour of them, aiming at following:

1. **To stimulate the creation of European consortia and joint ventures among different subjects (engineering firms equipment manufacturers, electric power companies, financing agencies) interested in investing in geothermal projects in Europe and abroad to cope with the competition from non European companies. This could be achieved by giving priority to programmes and projects including co-financing of European industrial partners for preliminary identification studies, prefeasibility studies (of the advance type, reimbursable during execution of the work) and plant implementation.**

   **This action could be focused specifically at Latin American and Chinese markets which currently appear the most open and "free" to EU operators.**

2. **To favour National Geothermal Associations, and the European Branch of IGA, in their non-profit making activities for the promotion, information, dissemination and transfer of experience and contacts within the world geothermal community. These organisations, together with the EGEC, should become the principal EU contact for geothermal energy matters such as the EU geothermal programmes and statistics reference, information for decision makers, awareness communication, promotion, contacts with other renewable sources association and other European industrial association, etc.**

3. **To support the newly created EGEC (European Geothermal Energy Council) among the European geothermal manufacturers and service companies which operate within Europe and abroad in a similar way to the Geothermal Energy Association in the USA. The EGEC would strengthen European consortia among energy operators wanting to invest in geothermal projects in Europe and**

**abroad, and assist European companies in competition with existing Japanese and US consortia.**

4. **The maintenance and improvement of the EU's existing research and financing programmes, from DGI, DGXII, DGXIII, DGXVI and DGXVII dedicated to energy projects including Alure, Phare, Tacis, Joule, Inco-Copernicus, Structural Funds, Altener, Synergy and Thermie. These programmes have in the past positively influenced research, testing and promotion of new geothermal applications in recent years as the knowledge of geothermal problems and opportunities has grown.**

5. **To promote the environmental benefits of geothermal energy through favourable financing condition such as:**

   - **tax exemptions or reductions for RE products;**
   - **tax incentives to be addressed to geothermal projects financing**
   - **financial incentives for end-users to buy equipment and services**
   - **loans and special interest rates devoted to investments in RE resources in general.**

6. **Geothermal energy should be included in specific "target projects" and demonstration projects such as the European Green Cities, which is supported by the EU Thermie programme, both as an environmental friendly resource and as an indigenous energy supply for saving imported fossil fuels. Examples of special target projects could be:**

   - **partial or total replacement of fossil fuels by geothermal energy for the generation of electricity in the Azores, the Greek islands, as well as Italy's small islands and the Canaries which would provide environmental and economic benefits to these communities. Both technical assistance and public relations activities are needed to promote geothermal electricity production in these areas (see "Campaign for take-off, paragraph 3.2.4 of integration of RE in 100 Communities [1]);**

   - **technical and financial support for demonstration projects in the use of medium temperature geothermal water for electricity production using binary fluids.**

7. **To establish an insurance system for EU countries in order to cover the geological risk which is an effective measure to stimulate and re-launch the geothermal European market and improve the exploitation of this renewable resource. This system could also be demonstrated within the EU and used as an example for analogous initiatives in other areas/countries of the world.**

[1] "Energy for the future: Renewable Sources of Energy - White Paper for a Community Strategy and Action Plan - 1997".

**8. Implement proper actions devoted to the systematic integration of geothermal energy into existing and new EU and national RE development programmes. This action should move in two directions:**

- **integration of geothermal energy in national and regional New and Renewable Energy development programmes since in some EU countries geothermal energy is not included and in some cases is not even considered as a renewable form of energy.**

- **integration of geothermal energy use in the development of new district heating systems and the rehabilitation of existing networks within EU countries and especially in countries which could become associated in the near future. This integration could start for rehabilitation and modernisation projects of large diffused district heating systems in different European countries (Agenda 2000, Russia and other European countries) financed by EU programmes (TACIS, PHARE etc.) or international financing institutions (WB, EBRD etc.). The integration of geothermal energy could become a compulsory condition, when applications are made for investment funds**

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**Special attention should be paid to the possibilities offered by the rapid expansion of direct use applications for geothermal energy in Central and Eastern European countries and CIS countries, where unexploited but plentiful geothermal resources have been identified. There is a long tradition of using geothermal energy for direct applications (mostly for balneology and greenhouses) in many of these countries, and most of the towns have district heating systems using water heated by hydrocarbons.**

**With education as well as financial and technical support, a significant reduction could be made in carbon dioxide emissions through replacement of coal and other hydrocarbons partly or totally with geothermal and other non-polluting energy resources. There is wide scope for the integration of indigenous energy sources in the space heating market in these countries.**

**9. Promote directives in order to acknowledge RE investments (including geothermal) with an extra price or a contribution for the $KWh_e/KWh_t$ produced which corresponds to the external benefit derived from the substitution of conventional energy sources. The relative funds could be achieved by a tax (green tax) charged on the $KWh_e/KWh_t$ produced through conventional sources. (Considering the present prevailing contribution from the latter the extra charge at the same should be negligeable in absolute terms).**

10. **Increase the use of information brochures and actions of the "Multi-energy" type, with the objective of increasing the level of information and confidence of using geothermal energy by decision-makers, private and public operators, town planners, designers, even within EU programmes. The establishment of a proper methodology for a cost evaluation of low enthalpy geothermal projects, possibly supported by software, would be a useful tool. Moreover, there is a great need for demonstration projects in individual countries to convince the public and decision makers of the viability of geothermal energy, both alone, and in integrated solutions with other locally available energy sources such as waste burning and biomass.**

11. **Promote a detailed study for the evaluation, in quantitative terms of the external benefits from substitution by geothermal applications. This evaluation should be based on statistical data from specific applications (electricity generation and direct uses) in EU countries and contrasted with comparable conventional options.**

12. **Considering the good development perspectives of this application, special attention could be devoted to the promotion and support for the GHP market via the followings steps:**

    - **decrease the cost for ground loop installation (standardised technologies with drilling companies, better access for the public to the drilling company information, etc.);**

    - **provide low interest loans for GHP installation;**

    - **provide better information for the public (full and easy access to information related to GHP technologies) and better co-ordination between active operators (drillings, companies, main features, engineering, etc.). A specific programme should be implemented, or the EGEC (European Geothermal Energy Council) could establish and manage a publicity campaign (similar to what has already been achieved in Switzerland and the USA), which is aimed at domestic users communities and even individual countries.**

    **The general public and decision makers should be informed of the fact that geothermal resources exist in every country and that these can be used to substitute environmentally degrading fossil fuels for every day activities such as the heating and cooling of buildings.**