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Geothermal energy – A local answer to a hot topic?

Report
Committee on the Environment, Agriculture and Local and Regional Affairs
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Summary

Geothermal energy, which is energy sourced from the Earth's heat, has long been known to man and exploited by him. Its use goes all the way back to antiquity. It is now used by 90 countries, in 24 of them for electricity generation. In certain cases it accounts for a fairly substantial – between 15% and 22% – proportion of all the electricity produced.

Geothermal energy is sustainable and non-polluting and also has the advantage of being widely available and not dependent on climatic conditions. The gradual depletion of reserves of fossil fuels and efforts to combat climate change make geothermal energy a potentially interesting method of meeting our energy needs. It is also likely to be more cost-effective than other sources of renewable energy.

However, the exploitation of geothermal energy still suffers from certain legislative and regulatory, and financial and economic, weaknesses.

The Parliamentary Assembly therefore recommends the use of geothermal energy as a means of combating climate change and stresses that in order to achieve this objective local elected representatives and political decision makers must take the necessary steps to inform the general public and, above all, potential investors, of its benefits. It also calls for strategic research programmes, financing and insurance schemes and adequate training.

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A. Draft resolution[1]

1. Geothermal energy is currently used in 90 countries around the globe, 24 of which use it to produce electricity. Geothermal energy is nothing new, having been used as an energy source as long ago as the 14th century.

2. Geothermal energy is an interesting solution to the worldwide dwindling gas and oil reserves. According to some experts, it even offers the best cost-effectiveness ratio of all renewable energy sources.

3. Furthermore, the Earth's heat is an abundant source of energy which pollutes little and has considerable potential, as its possibilities are still largely unexploited, particularly where private owners, urban heating networks or industry and agriculture are concerned.

4. The Parliamentary Assembly stresses that geothermal energy has a great many advantages, owing to its availability, its low operating cost, its integration in the sustainable energy mix and its positive impact on the environment.

5. The Assembly notes however that the exploitation of geothermal energy still suffers from shortcomings, mainly in legislative or regulatory terms (vague legislation, complex and lengthy administrative procedures, etc.) or of a financial or economic nature (investment costs still too high, inadequate risk coverage and insurance mechanisms, etc.).

6. Accordingly, the Assembly considers it expedient to set up common instruments, at European level, to facilitate investment in geothermal projects as well as financial investment intended to cover investors should technical problems arise.

7. The Assembly regrets in this respect that the public is sometimes reluctant to accept geothermal energy projects, owing to a generally recognised lack of information and awareness-raising.

8. In this context, the Assembly believes that local elected representatives and political decision-makers have a paramount role to play in making the general public and potential investors aware of the need for a green transformation and the potential of geothermal energy as an effective instrument in response to climate change.

9. Consequently, the Assembly invites the Council of Europe member states and observer states to:

9.1. foster the development of geothermal energy operations in their national energy strategies;

9.2. encourage the use of geothermal energy in all its forms, particularly locally;

9.3. encourage international co-operation in the transfer of technology and the financing of geothermal development;

9.4. increase realisation and awareness among the general public and potential investors of the advantages of geothermal technologies for a sustainable energy infrastructure;

9.5. take the necessary steps to set up strategic research programmes and encourage the exploitation of geothermal energy resources;

9.6. foster the introduction of financing and insurance schemes for exploration;

9.7. encourage the setting up of transfrontier co-operation schemes to finance surface measurements and test drillings;

9.8. introduce a European training and professional development framework;

9.9. draw up a map of geothermal energy resources at European level within the framework of co-operation between the geological research bodies of each country.

10. The Assembly also invites the Council of Europe member states and observer states to harmonise, through the introduction of common instruments, the system of risk guarantees and the regulatory and administrative regime for the use of geothermal energy.

11. Additionally, the Assembly invites the Congress of Local and Regional Authorities of the Council of Europe to encourage local authorities to be reliable partners in the development and operation phases of geothermal projects.

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1. . Draft resolution adopted unanimously by the committee on 29 April 2010.

B. Explanatory memorandum by Mr Rouquet, rapporteur

1. Introduction

1. "Geothermal" is the term that refers to both the science that studies the Earth's interior thermal phenomena and the technique that aims to exploit them. By extension, geothermic also relates to geothermal energy, sourced from the Earth's heat energy, which is directly used as heat or converted to electricity.

2. Much of the Earth's internal heat (62%) comes from the radioactivity of the rocks making up the Earth's mantle and crust. This is natural radioactivity generated by the decay of uranium, thorium and potassium.

3. Geothermal heat is an inexhaustible source of energy comparable to that of the sun.

4. Up to now we have used only a small part of the underground heat reservoir potential. Being a proven technology and controlled technically, nowadays, geothermal energy can be used for electricity, for district heating, as well as for heating and cooling of individual buildings. But the discovery of more accessible reservoirs has done little to encourage geothermal development.

5. Global processes provoked by the burning of fossil fuels can be positively influenced at a local level where sustainable, decentralised solutions with regard to heat and electricity supply can be realised. New technologies, among which geothermal shows a high potential, will come into play at much larger scale than experienced so far.

6. As gas and oil supplies dwindle worldwide, the use of geothermal energy can become an attractive solution, as it is already proven in some European countries.

7. This is also one of the reasons why participants of the recent World Economic Forum in Davos concluded that geothermal energy will offer the best possible cost-effectiveness of renewable sources. Furthermore, geothermal energy can be used for base-load supply.

8. Legal, institutional, regulatory, environmental and social barriers have severely constrained the implementation of geothermal projects in Europe. The potential is mainly undeveloped, which is mainly due to inadequate framework conditions.

2. Background

9. Humankind has always known how to take advantage of geothermal energy, having used it in heating and cooling for thousands of years in China, ancient Rome and the Mediterranean and for more than one hundred years for electricity.

10. The use of geothermal energy is nothing new in Europe. For example, a hot spring in Chaudes-Aigues (Auvergne, France) was used in the 14th century for the first district heating and a low temperature (81°C) geothermal resource has already been exploited, since the late 1960s, at Paratunka, Russian Federation, combining power generation (680 electric kilowatts (kWe) installed capacity) and direct uses of the waste heat for soil and greenhouse heating purposes.

3. The current situation worldwide

11. Geothermal energy is used in 90 countries around the globe, 24 of which use it to produce electricity, including China, Iceland, United States, Italy, France, Germany, Portugal, Turkey, New Zealand, Mexico, Nicaragua, El Salvador, Costa Rica, Russia, Indonesia, Philippines, Japan and Kenya.

12. In 2005, five of these countries obtain 15% to 22% of their national electricity from geothermal. Yet, only a small fraction of the potential has been developed and used so far. This potential is still to be exploited both for direct use and for electricity generation. Today, total installed geothermal capacity is 9.7 gigawatts (GW). Most European countries already have considerable geothermal installations. The same applies to the United States of America, Central America, Indonesia and Kenya in the African Rift Valley. El Salvador, Kenya and the Philippines especially play a key role in geothermal energy supply.

13. In 2005, the world's geothermal capacity was estimated at a total of 8 933 megawatts (MW), broken down as follows: Asia 3 290 MW; North America 2 564 MW; European Union 823 MW; other European countries 301 MW; Australasia 441 MW; Central and South Americas 1 377 MW; Africa 128 MW. Geothermal

energy is Iceland's main energy source but it is El Salvador which is the biggest consumer – 22% of the electricity generated there is produced by geothermal energy (2005). In addition, geothermal heat provides heating and hot water for about 87% of Iceland's inhabitants.

14. One of the largest geothermal sources is located in the United States. The Geysers, some 145 km north of San Francisco, began production in 1960 and now has a capacity of 900 MW. It comprises a collection of many electric power stations using steam from over 400 wells.

4. The use of geothermal energy in Europe

15. The largest geothermal district heating systems within the European continent can be found in the Paris area of France, with Austria, Germany, Hungary, Italy, Poland, Slovakia, among others, showing a substantial number of geothermal district heating systems.

16. As far as geothermal electricity is concerned, the vast majority of eligible resources is concentrated in Italy, Iceland and Turkey due to young volcanism.

17. High temperature resources are mainly concentrated in volcanic islands (the Azores for Portugal, the overseas *départements* for France, the Canary Isles for Spain) and in Greece, which is one of the most favoured countries in Europe for development of high temperature resources.

18. Medium temperature resources exist in some concentrated locations (for example, in Hungary and Germany).

19. Central Europe has mostly low-energy geothermal resources in deep sedimentary basins. Hungary, due to its unique geological position upon the "geothermal hot spot" Pannonian Basin, has very favourable resources.

20. Iceland has led the way in direct uses of geothermal energy, mainly in greenhouse and district heating (89% of the total domestic heating demand) and is increasing its electricity production, which in 2006 reached a 420 MW installed capacity. Although significant, this capacity ought to be compared to the huge potential of the island, estimated at 4 000 MW, a figure far above national power requirements, 1 500 MW.

21. In Guadeloupe, at Bouillante, not far from the Soufrière volcano, four exploration wells were drilled in 1984, one of them to a depth of 300 metres, leading to a decision to install a 5 MW power station. Very close to that site, three new, deeper production wells (averaging 1 km) were commissioned in 2001 and a power station built in 2003 (Bouillante 2) made it possible to generate an additional 11 MW by the end of 2004. This new energy provision covers around 10% of the island's annual electricity needs.

22. In mainland France, deep wells have been drilled, most recently in 2005, to a depth of around 5 000 metres in Soultz-sous-Forêts in Alsace, in artificially fractured rock. In addition, 30 urban heating networks, using low-energy geothermal energy, have been operating successfully in the Paris region for about thirty years. Heat pump installations using groundwater continue to be developed in the Paris region and elsewhere as these heating and cooling techniques are particularly well suited to the tertiary and residential sectors.

23. In Germany, a 3.4 MW power station in Unterhaching (near Munich), generating heat and electricity in parallel, has been undergoing test runs since 2007. Drilling is to a depth of 3 350 metres, with a flow-rate of 150 litres of water per second at a temperature of 122°C.

24. In the wake of the first oil crisis, several initiatives to exploit geothermal energy were launched in certain European countries. However, a number of projects had to be stopped for financial reasons, as well as on technical grounds as the technology was not fully mastered, which may have given geothermal energy itself a poor image, all the more so as, in the same period, fossil fuel prices had substantially dropped.

25. Today, these technologies have been mastered and the likely trends in oil prices now make them a more attractive prospect.

26. It is therefore not astonishing that geothermal energy was the highest growth sector for investment in 2008, with investment up 149% and 1.3 GW of new capacity installed.

5. The principles of exploitation

27. The deeper the borehole into the Earth's crust, the higher the temperature rises. On average, temperatures increase by 30°C for every kilometre drilled. The thermal gradient depends greatly on the region of the globe concerned. In New Zealand for example, water already exits in the subsurface at very high temperature, in the form of steam.

28. There are a number of technical approaches to geothermal energy, each very different, geared to highly diverse consumer profiles and investors, such as:

– stimulated geothermal energy (EGS, Enhanced Geothermal System), which uses the heat of very deep-lying artificially fractured rocks (3 000 to 5 000 metres) to produce electricity and heat;

– medium-depth geothermal energy (up to 3 000 metres), which heats water to a temperature high enough to be used directly in a heating network;

– geothermal energy for domestic or tertiary use, which uses heat pumps for the heating and cooling of buildings (air-conditioning);

– geothermal energy for agricultural or industrial use, which may be used to heat greenhouses for example or delivering process heat for industrial purposes..

29. Geothermal energy has a huge potential. In the United States the famous MIT (Massachusetts Institute of Technology) produced a theoretical study in 2006 showing that an enormous energy reserve existed between 3 000 and 5 000 metres deep, which, if harnessed, could easily cover all the energy requirements of the entire United States. Similarly, the so-called TAB study from the Office of Technology Assessment at the German Parliament (TAB) showed the same for Germany in 2003.

6. Geothermal energy development: opportunities and challenges

6.1. Why geothermal energy in Europe?

30. In recent decades, growing concern on environmental issues has spread across Europe and the demand for energy has also been shooting up. It is clear that an easily exploitable energy source is needed to give a boost to local activities and support self-sustaining economic growth in Europe.

31. There are many advantages to geothermal energy which make this technology extremely valuable for electricity generation and direct use:

– almost universally available, geothermal energy provides an answer to all energy needs: electric power, heating, cooling, hot water;

– being a base-load energy, geothermal energy is available twenty-four hours a day, seven days a week from domestic sources; so it generates continuous and reliable power, independent of weather conditions;

– as no fossil fuel is used for the power generation, geothermal power plants provide heat and electricity at stable and predictable costs;

– once the geothermal plant is built, which represents a high investment, geothermal power production has low operational costs and is effective for decentralised distributed application;

– geothermal energy utilisation can be cost competitive with conventional energy resources and produce continuous income for decades;

– no burning of fossil fuels is involved and no man-made emissions, such as CO_2, will affect the area; no radioactive waste is produced;

– moreover, geothermal fluids can be channelled, via geothermal wells and collecting lines, to power plants, thus concentrating natural emissions, which would otherwise contaminate the surrounding soils and atmosphere, to a single point;

– geothermal energy contributes to a sustainable energy mix based on renewable energies; it helps diversify energy supplies and increases energy independence from fossil fuel imports;

– using decentralised energy technologies creates employment in local communities at much higher rates than many other energy technologies; there are economic opportunities for new industries and new industrial and craft jobs and deep geothermal energy projects potentially bring jobs to former mining areas;

– contrary to power plants with huge land demand, a geothermal plant does not need much space; it has a low visual impact.

6.2. Hurdles hindering a wider use of geothermal energy on the European continent

6.2.1. Technical barriers

32. There are a number of technical difficulties that can be met by project planners, developers as well as operators when developing geothermal projects:

6.2.1.1. Environmental considerations

33. Although it can be assumed that geothermal production is an environmentally friendly and renewable solution, some negative aspects can appear. Most opponents to geothermal energy disapprove of geothermal projects because of noise, threats to rare animals or plants or the risk of micro-seismicity.

34. Possible nuisances caused by geothermal plants could be:

– air emissions;

– noise pollution through cooling systems during the utilisation phase of geothermal energy; the short drilling phase is also a source of noise;

– visual impact: if the geothermal boiler of a district heating system cannot be dissimulated in a building, it may be considered that the development of a geothermal power plant in the middle of the landscape would have a negative impact.

35. These nuisances can generally be solved technically; examples are:

– the reinjection of the water and circulation in a closed loop can inhibit odours;

– well pressure management can hinder degassing and thus smells; however, reinjection is not compulsory in all countries;

– in a high density location (as is the case for district heating) some precautions can be taken such as avoiding night drilling and/or isolating some equipment.

6.2.1.2. Deep geothermal projects and micro-seismicity

36. Under certain tectonic conditions, the construction and the operation of geothermal power plants may trigger micro-seismicity. The same phenomena occur frequently in natural gas and oil exploitation and in tunnelling. This is related to the particular geological structures in the respective region.

37. In August and September 2009, the residents of Landau (Germany, Rhineland-Palatinate) experienced some micro-seismic sensations.

38. Again in Germany, in the southern Black Forest town of Staufen-im-Brisgau, there was cracking in several buildings and the ground rose at a rate of one centimetre per month. A link has been established between these phenomena and geothermal near-surface drilling operations. They are the consequence of the injection of water into a subsoil containing anhydrite, a mineral substance that transforms into gypsum when it comes in contact with water, resulting in a volume increase of 60% and subsequent damage.

39. A Soultz-type geothermal project was launched on a commercial basis in Basel in Switzerland in 2006. In December 2007, stimulation experiments resulted in a mini-earthquake that was felt by local inhabitants. As a result the project was definitely stopped in 2009. Several projects have been launched in the upper Rhine Valley, based on the Soultz experience. These include the Landau (3 MW and district heating) and Insheim projects. Once again, micro-earthquakes associated with these projects have generated fears among local inhabitants. A European project is to be launched on this subject to throw more light on the physical mechanisms underlying these induced earthquakes. The French Geological Survey (BRGM) and the University of Strasbourg will participate in this research.

40. However, these are the sorts of problems associated with the development of any new technology. Operating and drilling difficulties affecting installations established following the first oil crisis and more recently are no longer applicable, thanks partly to our greater mastery of the technology and partly to a much better understanding of the geological conditions that make sites suitable for geothermal energy generation.

6.2.1.3. Adequacy between resources and need

41. Another barrier to the further exploitation of geothermal energy relates to the fact that the potential should be adequate for the needs on the Earth's surface.

42. Even if a potential exists for the development of district heating, exploiting it will be interesting only if population density and the need for heat production are adapted to the resources available so as to provide heat economically. Geothermal heat plants are located close to densely populated areas or local industry with a high heat demand.

43. For electricity production, the problem of matching demand and resources is less significant as electricity can be transported over longer distances and, despite increasing efficiency, demand keeps increasing.

6.2.2. Grid-related barriers

44. Already in the near future, national regulatory authorities in Europe will have to facilitate the integration of renewable energy into the power grid and transmission system operators will have to grant electricity from renewable sources priority dispatch. This will help adjust the balance of the power markets, at present heavily tilted towards conventional fuels.

6.2.3. Non-technical barriers

45. After 1986, the sudden collapse of oil and gas prices caused an equally sudden loss of interest in geothermal development in many European countries with the consequence that some operations were shut down mainly due to unexpected financial difficulties. Fossil energies were attractive again and this provoked loss of interest from investors and public owners.

46. Nowadays, the main reason for low geothermal energy production in Europe is the existence of non-technical barriers that hinder the efficient exploitation of the geothermal resource. It is therefore necessary to overcome these hurdles that influence geothermal projects at different stages and in various fields of the project and hinder the growth of the geothermal sector in Europe.

6.2.4. Legislative and regulative barriers

47. The present lack of legal compliance and regulation for geothermal energy exploitation in some European countries is inhibiting the effective exploitation of this underutilised resource.

6.2.4.1. Equivocal legislation

48. The relevant legislation is contained in laws on mining, energy, environmental matters, water management and geological projects, sometimes in a conflicting way, and the licensing procedure for geothermal facilities is also rather complex in most countries.

49. In some countries, there is not even a specific law for geothermal energy and different ministries are responsible for geothermal energy applications, which makes the predictability of legal decisions difficult.

6.2.4.2. No long-term guarantee for the exploitation of the resource

50. In some countries, there is no legal protection guaranteeing the long-term ownership of the resource. In those cases, neither the exclusive usage of the field is guaranteed nor is the usage of the necessary water reservoir secured by the law.

6.2.4.3. Complexity of administrative procedures and length of administrative proceedings

51. Major administrative barriers arise from the complexity of administrative procedures and the length of administrative proceedings. The high number of authorities involved, the lack of co-ordination between different authorities and little awareness of benefits of geothermal energy in local and regional authorities also constitute non-negligible problems.

6.2.4.4. CO2 storage endangers the development of geothermal energy

52. It is feared that CO_2 capture and storage laws, as currently being discussed in many European countries, will slow the development of clean energy sources, in particular geothermal energy.

6.2.5. Financial and economic barriers

53. There are a number of financial and economic aspects, especially for deep geothermal projects, which hamper heat and/or electricity production.

6.2.5.1. High upfront costs: high investments for drilling and testing

54. Compared to other renewable energy technologies, deep geothermal energy projects have non-negligible upfront costs (mainly due to the costs of exploration, like seismic investigations and drilling exploration wells).

55. This is stressed by the existence, in some countries, of high additive costs (that is, exploration and/or exploitation permission costs, the cost of geological geothermal data).

56. Geothermal energy does not yet have the critical mass that would produce a decrease in investment costs.

6.2.5.2. Additional cost for the construction of district heating networks

57. In case of construction of a completely new geothermal project, the construction of a new district heating network leads to higher investment costs.

58. This could also facilitate the development of geothermal energy projects in combination with district heating networks that currently are supplied by non-renewable energy.

6.2.5.3. Further cost efficiency needed for drilling

59. There is a lack of drilling rigs for geothermal energy. The high demand for suitable drilling equipment increases the overall drilling costs.

60. Parallel to that, the lack of geothermal projects makes it difficult to develop a geothermal drilling industry dedicated exclusively to geothermal energy projects.

6.2.5.4. The particularity of geothermal energy: the existence of geological uncertainties

61. One of the most important barriers is the geological risk of the non-discovery of adequate resources for the project: money has to be spent whilst the success of the project has not been proved. There is also a long-term geological risk of facing a resource with lower-than-estimated temperature, higher-than-estimated mineralisation, or difficult reinjectivity.

62. The danger that the resource decreases or disappears before reimbursing the cost of the equipment as well as the risk of damage affecting the wells, the material and the equipment of the geothermal loop during the exploitation period should not be underestimated.

6.2.5.5. Lack of an insurance mechanism insuring the risk of non-discovery of adequate resources

– drilling insurance (technical risks)

– operation insurance (machine breakdown)

63. Geological risk insurance needs to be available for a company which undertakes exploration and development of a geothermal field.

64. Geological risk insurance mechanisms which insure the presence and the quality of the resource in the reservoir (flow rate and temperature) are only offered in a few countries (in Germany, France and through the Geofund). Traditional insurance policies do not offer any specific solutions for the risk of non-discovery. A risk-sharing instrument helps to overcome this barrier in order to foster investments in geothermal energy projects.

65. Furthermore, there are private enterprise insurance solutions available which have to be negotiated on an individual basis and include high insurance premiums.

66. For example, in France, a geological risk insurance was developed to offer a long-term guarantee to cover the possible modification in quality and quantity of the resource.

67. The development of geothermal energy in France was encouraged by the implementation of a global scheme involving financial guarantees designed to cover project investors against the geological uncertainties specific to this activity: the risk during the drilling phase of not obtaining geothermal resources matching the flow rate and temperature requirements necessary to ensure the profitability of the planned operation.

68. To take over the risk of non-discovery, the German Ministry for Environment (BMU) has developed a risk mitigation instrument focused on geothermal drilling projects.

69. France, Germany and Bulgaria have a system of risk insurance for geological risks covering the risk of not discovering the necessary quantity and quality of the resource.

70. This kind of insurance is particularly important for pilot technologies that could have application problems if a financing bank requires such insurance contracts to guard against losses during the operation.

6.2.5.6. Long payback period

71. Deep geothermal projects are projects with a long payback period.

6.2.5.7. Low outcomes

72. For many geothermal projects, outcomes appear low. In some countries, royalties and other taxes during exploitation reduce the sources of incomes. These expenses are sometimes too high compared to the annual heat sales.

6.2.5.8. Short depreciation period for district heating and wells

73. Another difficulty comes from the short depreciation period for district heating and wells.

74. Longer depreciation periods would lead to lesser expense in profit and loss accounts and therefore could support the economic profitability of a geothermal project.

75. Special deprecation is available in some countries but only for some equipment or instruments.

76. In case of a non-fixed depreciation period for wells for example, it can be assumed that a period adapted to the lifetime of the drilling, corresponding to at least thirty years, is theoretically possible as the geotechnical period of use of a geothermal well.

77. But the longer the period is, the more difficult it will be for it to be accepted by authorities or by banks. With special depreciation rates, governments can also support investments in certain cases.

6.2.5.9. Low feed-in tariffs

78. Feed-in tariffs regulated by law are a revenue-neutral way of making the installation of geothermal energy more appealing.

79. A system of feed-in tariffs for geothermal electricity ensures a certain amount of income but this is not always high enough to ensure an attractive outcome. Moreover, the remuneration is generally only given for the net electric energy, and not for gross production capacity. This reduces substantially potential revenues from a geothermal project.

6.2.5.10. Long-term risks: lack of security for investment

80. In some European countries, heat and electricity sales are not guaranteed over a long period. Investors in geothermal heat and electricity production projects need to assess the heat and electricity market to make sure that electricity and heat sales are high enough during the long payback period needed.

81. Finally, competitiveness with fossil fuels is a key factor in the development of geothermic projects. As the relatively cheap prices for fossil fuels make it difficult to launch geothermal projects, the oil price fluctuations play an important role when considering if geothermal energy might be an option.

6.2.5.11. Lack of innovative financing instruments adapted to the special needs of the geothermal sector – Effective tools for risk mitigation required

82. Most financial instruments are not dedicated to geothermal energy in general. These instruments do not consider the particularity of geothermal projects: high upfront costs during the exploration and pre-feasibility phase and security concerning the size and output of the energy supply project only after completion of the first successful wells. But a significant sum has to be spent before the resource is proven. This explains the lack of financial institutions ready to participate in the early stages of a project. They are reluctant to invest while the profitability of the project has not been proven.

83. Equity from the company's own resources or grants from public bodies could cover these expenditures. Private equity investors will expect a high rate of return during the first stages of the project due to the risk their investment still faces. Finally, classic project finance schemes can be used only at a very late project phase.

84. Currently, the European Investment Bank does not fund projects in the early stages but only projects which have proven their economic viability.

6.2.5.12. Special bank facilities

85. Very few banks propose special bank facilities with low interest loans adapted to geothermal project characteristics.

86. Specific financial guarantees, designed to protect project investors against the geological uncertainties specific to this activity, could secure the financing of a project.

87. The investor must have access to adequate capital to move a geothermal project into the later stages of development and he must be willing to put that capital at significant risk. This combination of uncertainty and difficulty in finding money multiplies the risk of geothermal projects.

88. Getting a loan for investment is difficult as most banks will not lend money to high-risk projects.

89. Special bank facilities with low interest loans are rarely possible at the moment, except in Germany and Iceland.

6.2.5.13. Tax reductions

90. Tax reductions are an effective governmental incentive and concern both electricity production and heat production. They can help to promote increased capital investment in geothermal projects.

6.2.5.14. Grants

91. Public grants are the only instruments proposed to complement equity capital or to finance exploration phases. Grants can support the financing of investments.

92. Subsidies are offered at national level, but mainly at regional level. They cover mainly the investment phase, for drilling wells, but also the purchase of equipment for the central production and can cover 30% to 40% of the investment.

93. France offers special subsidies for feasibility studies that are a first step to financing the exploration phase, whereas the Portuguese regional programmes are more oriented to the development of pilot projects.

6.2.5.15. Tradable certificates and quota systems

94. The generation of green certificates or the possibility for a geothermal project to participate in emission trading could provide additional sources of income.

6.2.5.16. Venture capital

95. Venture capital can be an adequate financial instrument, even though it is dependent on well-functioning financial markets both for loan finance and for the ultimate listing of successful projects.

96. Although venture capital is usually available everywhere or negotiable, as yet it is not attracted to geothermal energy projects. For example, venture capital is the most important financing source for geothermal projects in Germany.

97. Venture loans are offered in Iceland and by the European Investment Fund.

6.2.5.17. Funds for research and pilot projects

98. Allocating funds for research and pilot projects could be another way of fostering geothermal energy but nothing systematic can be found at the European level.

99. Some countries also dedicate money to promoting research and development of new demonstration projects that geothermal energy can benefit from.

100. These instruments should permit the launching of new technologies, for example to develop EGS Systems that will enable the production of electricity where no natural resources exist.

101. On the whole, all these instruments are a way of increasing profitability, by offsetting the high upfront costs and payback period of the project so as to overcome the financial risk barrier and attract investors.

6.2.5.18. Growing necessity of common European instruments

102. Some common instruments exist across Europe that facilitate investments in geothermal projects. However, the lack of harmonisation is obvious.

103. The development of geothermal financial instruments at the European level to support geothermal projects in their early stages might be an interesting aspect to consider.

104. A European solution should mainly try to solve two aspects: the lack of financing for the exploration phase and the risk of inappropriate quality or quantity of the geothermal resource compared to the expectations for the project. This solution would have to take into account, on the one hand, project specific aspects, which have to be fulfilled, and, on the other hand, the investment environment of the project.

105. Therefore, a combination of financing schemes and incentives can be a key point for the economic success of geothermal projects.

6.2.6. Awareness and acceptance barriers

6.2.6.1. A predominantly negative public opinion in Europe

106. If public opinion is globally positive to geothermal energy, deep geothermal projects sometimes suffer from low public acceptance.

107. In many European countries, awareness of geothermal energy is still quite poor.

108. In 1985, a double flash 2 MW pilot power plant was installed in the high enthalpy field of Milos, Greece, and operated intermittently until 1989. However, the plant was then shut down because of environmental protests due to sulphur emissions into the atmosphere. Because of the unfortunate fate of the Milos electrical plant, a geothermal power plant planned in Nisyros was rejected.

109. Even though citizens are becoming more and more concerned by environmental issues, they are not always ready to accept such renewable projects. This is explained in some cases by local environmental difficulties.

6.2.6.2. Lack of political will

110. The formulation of national political objectives in the sector of renewable energies is an important factor for the development of public awareness.

111. Globally, there is a political will to expand renewable energy in general, including geothermal, but it is not always translated into operational action.

112. In some European countries, geothermal energy is not mentioned in the national renewable energy plan.

113. National research and development funding schemes should clearly have geothermal energy research, pilot projects and spin-off activities amongst their priorities.

6.2.6.3. Lack of information

114. There is currently a lack of information about geothermal energy and geothermal possibilities, for the public but also more generally for all possible actors in a geothermal project.

115. Clear market signals as well as information campaigns proactively targeting suppliers can help to overcome this obstacle.

116. The information infrastructure on geothermal potential is well developed in very few countries (such as Germany, which disposes of online tools like GeotIS)

117. Improved information regarding resources in emerging European markets will allow more companies to enter the geothermal industry, especially those with multiple synergies with the geothermal industry, such as oil and gas service companies.

118. Finally, dissemination of information is necessary to increase the public and stakeholders knowledge.

6.2.6.4. Lack of co-operation

119. Many stakeholders participate at different stages in a geothermal project: consumers, suppliers, developers, governments, operators and financial institutions. They all have multiple interests. In order to successfully manage the development of a geothermal project, businesses, experts, authorities and civil society groups need to co-operate and work to implement “win-win” situations.

120. The sharing of competence could have a positive impact at different levels: facilitating insurance proposals, decreasing drilling costs and raising awareness among financial institutions that work at the European level.

121. Drilling companies in the gas and oil sector have a number of diversification opportunities in the drilling and exploration phase of geothermal projects. There are various techniques and expertise that can be transferred from oil and gas to geothermal exploration. Better co-operation between these sectors is therefore crucial.

122. Additionally, clustering of wells leading to bigger power plants could lead to economies of scale and decreasing investment costs.

123. The setting up of technology platforms, which bring together companies, research institutions, the financial world and the regulatory authorities at the European level, might help to define a common research agenda and strategies which should mobilise a critical mass of – national and European – public and private resources.

124. The development of European solutions and a common European market can reduce costs and thus make geothermal power a more competitive energy source compared with both conventional and other renewable energy sources.

6.2.6.5. Training, professional accreditation, certification

125. Training, professional accreditation, certification and awareness training, especially for the instructors of ground source heat pump designers and drillers, need to be improved considerably as there is currently a lack of certification regimes or incompatibilities between member states.

126. This implies the development and mutual recognition of accreditation and certification schemes for installers of small-scale renewable energy installations (and notably GSHP installers).

127. All barriers should be overcome in order to boost development of geothermal energy projects at a European scale.

7. The role of political decision makers

128. Growth in the geothermal sector must be complemented with reliable government support.

129. The experience of local elected representatives is important here, as the main difficulty is very often to convince decision makers, companies and engineering practices to consider these issues without fear or prejudice. Insurance- and approval-related matters are other difficulties to be overcome.

130. It is necessary, therefore, to identify the sticking points still preventing more widespread use of this technology and, above all, its appropriation by all the players in the economic and industrial system, without which there can be no green transformation.

131. At a time when the global crisis has grave ramifications for the economies of many Council of Europe member states and when a lot of European citizens have expressed their environmental concerns at the ballot box (particularly in the European elections of June 2009), it is crucial for existing companies to realise the need to go green. One of the tasks of the political decision makers is to accompany them in that transformation.

132. The example of the photovoltaic sector shows that states can give a decisive boost to the development of geothermal energy if tools are well designed and adapted to the particularities of geothermal projects.

133. Continued government support will bolster growth rates.

134. Financial incentives for geothermal energy development, such as interest-free subsidies, low interest long-term credits or subsidies for experimental and R&D projects are needed and governments can provide a framework for this.

135. Political leaders can both enhance support for start-ups and micro-enterprises, through technical assistance and grants, as well as other financial instruments such as loans, equity, venture capital and guarantees, and highlight the added value of undertaking these actions.

136. If a project is, for example, planned by the public sector (which might, above all, be the case for district heating) an insurance solution can lower the risk to a level that enables implementation of the project. In that case, insurance mechanisms seem to be necessary.

8. Outlook

137. Geothermal energy is a renewable energy source with great potential that is largely unexploited. With the steady progress in research on geothermal energy, exploitation systems will steadily improve and the market share of geothermal energy production will increase.

138. The most promising areas are the building of new district heating networks, optimisation of existing networks, and the development of new and innovative applications of geothermal energy in industry and agriculture.

139. Meanwhile, a number of such applications have been developed and some of those have already been demonstrated (snow-melting and de-icing, district cooling, etc.). Some applications are particularly promising, such as seawater desalination due to the coincidence, in many places, of water scarcity, seawater availability and geothermal potential.

140. Some technologies for exploitation of deep geothermal energy are now mature. However, this potential appears to be not sufficiently exploited.

141. Established countries will continue to invest in geothermal power and new European countries will explore opportunities. This will lower initial capital costs and attract drilling and other companies to invest in the sector. Technological evolution can be expected in both power and heat, and towards improving plant efficiency and decreasing installation and operational costs.

142. Therefore, in the near future in Europe, the advantages of geothermal energy as an environmentally friendly energy should be highlighted together with its application in low-cost and soft technologies, particularly when both resource and heat demand coincide.

9. Conclusion

143. Geothermal energy needs to gain its rightful position in the European energy market. The increasingly urgent need to curb climate change is proving to be an effective catalyst for the European geothermal energy industry.

144. The main objective needs to be the promotion of collaboration between public organisations and the private sector to encourage the development of geothermal energy among different authorities. In particular, political decision makers need to focus on the implementation of political instruments and legislation that help to enhance the development of this renewable energy. Some legislative or regulation barriers can indeed trigger economic hurdles.

145. Additionally, an adequate financial package has to be given in advance so that companies can effectively plan a project's execution.

146. The main barrier for the development of the European geothermal sector is the geological risk of non-discovery of resources: investment has to be made while the success of the project has yet to be proved.

147. Public geological risk insurance systems have been developed in very few countries. They should be extended to all European countries. The current approach to the decision on whether to launch a geothermal energy project is mainly economic and financial. The cost of fossil energies is then used to analyse the competitiveness of a project. But this approach does not take into account the external cost or environmental benefits.

148. The cost difference may be too small to decide in favour of a geothermal system. Energy policies could play a major role in changing such decisions.

149. Developing common European solutions could be interesting from many points of view. Indeed, the sharing of competences could have a positive impact at different levels.