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TAB

Possibilities for geothermal electricity generation in Germany

Summary

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SUMMARY

The aim of this report in the context of monitoring »sustainable energy supplies« is to study the possibilities and problems of geothermal electricity generation in Germany.

THE TECHNICAL POTENTIAL OF GEOTHERMAL ELECTRICITY GENERATION

The estimates given here of the technical potential of geothermal electricity generation in Germany show clearly that geothermal energy represents in principle a serious option for future energy supplies, even if only a fraction of the estimated potential can actually be exploited. Estimates at this level of detail are presented for the first time for the whole of Germany. However, further detail in the figures is needed at regional and local level.

The estimates for technical potential should be seen as upper limits, because, depending on the type of reservoir, the techniques for exploitation have not yet been fully developed, or the characteristics of the resources needed for exploitation are not known or present on a broad scale. The total technical potential for geothermal electricity generation is around 1,200 exajoules (c. 300,000 TWh), which represents some 600 times German annual electricity demand of c. 2 exajoules. 95% of the potential is from crystalline rocks, 4% from fault zones and around 1% from hot water aquifers. The additional potential from thermal energy (heat in cogeneration operation) is around 1.5 times the potential from electricity generation if no heat pumps are used, and 2.5 times if heat pumps are used.

Specifically, the probability of success in achieving (economically acceptable) minimum levels in thermal water production (minimum flow rates) and reservoir temperatures differs for the three types of reservoir. Exploitation of crystalline rocks using the hot dry rock concept is least dependent on natural conditions, and exploitation of hot water aquifers is most dependent. The different level of dependence on geological conditions results in specific problem areas for each of the three reservoir types. In addition there are uncertainties caused by the assumptions made for factors in winning.

Allowing for sustainability aspects (low natural heat flow etc), the technical potential should only be developed in stages over a very long period. The present

report assumes a period of 1,000 years. With a technical potential of 300,000 TWh, this results in annual technical potential supply for geothermal electricity generation of c. 300 TWh/y, or around half of current gross electricity generation.

The technical potential demand for geothermal electricity generation without cogeneration, where estimates include restrictions on demand, is around 290 TWh/y, assuming that the total base load in German electricity generation is supplied from geothermal energy.

If on the other hand we assume use in heat-power cogeneration – which would be desirable in economic and ecological terms – the technical potential demand for electricity is defined by the quantities of heat available for use in the energy system. Making the initial assumption that total low temperature heat demand in Germany could be met from geothermal installations, and on the basis of the demand in the year 2000, the theoretical upper limit for geothermal electricity generation in cogeneration plants is c. 140 TWh/y, or some 25% of gross electricity generation in Germany.

To get a more realistic estimate, the share of low temperature heat demand which could be supplied through heating grids was calculated. If this amount of heat was provided solely by geothermal cogeneration plants, this would mean associated geothermal electricity generation of c. 66 TWh/y. This option would require substantial expansion of the heat distribution grid.

Such expansion is not very likely, even in the future. As a result, it was assumed in a further stage that »only« the lower temperature heat fed into existing district heating grids would be supplied by geothermal cogeneration plants. This yields associated geothermal electricity cogeneration of c. 10 TWh/y, corresponding to around 2% of German annual gross electricity generation.

Estimates on technical potential demand particularly illustrate the problems associated with more extensive use of geothermal electricity generation. Economic geothermal electricity generation can probably only be achieved with heat-power cogeneration. This makes potential demand for heat a major constraint. Even replacing each and every existing district heating plants would – as shown above – permit geothermal electricity cogeneration of only 2% of German gross electricity generation. This is an order of magnitude which still represents a contribution towards reducing energy-related environmental impacts. but has limited relevance for the energy industry.

THE STATE OF THE ART AND PROSPECTS FOR DEVELOPMENT

There are very wide differences in the state of development of key technical elements required for integration of geothermal electricity generation or heat-power cogeneration into an overall system. While e.g. drilling technology – as a key technology in the petroleum and natural gas industry – is technologically mature, stimulation technology is still in the pilot stage.

Further development of stimulation technology to enhance the yield of geothermal reservoirs is of outstanding importance, as this would make possible the exploitation of vast potential energy, particularly in crystalline rocks (hot dry rock technology). Stimulation technology is also important in reducing the prospecting risk in drilling aquifers and fault zones. There is also still major potential for optimisation and further development in plant engineering in power plant technology.

The integration of the individual components into an overall system is currently being pursued in various pilot projects. It can be assumed that geothermally generated electricity will be fed into the German grid in the course of the next few years. Germany's first geothermal power station is to be commissioned in Neustadt-Glewe in Mecklenburg in autumn 2003.

THE COSTS OF GEOTHERMAL ELECTRICITY GENERATION

The comparison of electricity generating costs made here shows that geothermal electricity generation based on existing technologies and processes is a comparatively expensive option. Its electricity generating costs are more or less significantly greater than those of other regenerative options (wind, hydropower and biomass) and much higher than the electricity generation costs of the fossil options considered (hard coal, natural gas). Only electricity from photovoltaic generation is (much) more expensive.

However, in evaluating these results it must be borne in mind that the cost estimates presented for geothermal electricity generation are heavily dependent on the assumptions adopted. »More favourable« assumptions, e.g. for thermal fluid temperature and thermal water pumping volumes, would lead to considerably lower cost estimates.

Another point to be considered in particular is that the technology for geothermal electricity generation is still in an early stage of development and use and still has great development potential which gives grounds for expecting further cost savings.

Finally, it must be considered that in cost comparisons the substantial advantages of geothermal and other renewable energies in external costs of electricity generation compared with fossil fuels have not been taken into account (Hohmeyer 2001).

THE ENVIRONMENTAL IMPACT OF GEOTHERMAL ELECTRICITY GENERATION

Seen from our present perspective, the environmental impact of geothermal electricity generation of constructing the plants, normal operation, possible accidents and decommissioning is small. With all the environmental impacts quantitatively studied – greenhouse effect, acidification, primary energy consumption – geothermal power shows a similarly favourable balance as other renewable options for electricity generation. With regard to CO_2 emissions in particular, it performs significantly better than electricity generation from natural gas (a factor of 5) or hard coal (a factor of 10). Geothermal electricity generation could accordingly make a substantial contribution towards climate protection. Use of the associated heat can further enhance the existing very good environmental properties of geothermal electricity generation.

NEED FOR ACTION

There is need for action particularly with regard to realising the potential for cost savings of further development of the technology, reducing prospecting risks and securing investment risks, and the problems of using the large quantities of heat arising in heat-power cogeneration.

If the intention is to pursue seriously the goal of use of geothermal resources on a scale relevant to the energy industry, existing state support for this option would have to be strengthened and supplemented. Promotion of technologies and projects for geothermal electricity generation in the context of the German Federal Government's Future Investment Programme (ZIP) should be strengthened. The duration of the programme should be extended by at least five years, in order to initiate more projects for different location conditions. Accompanying studies to demonstration projects should be promoted with the goal of improving acceptance of integration of the overall systems into the energy market.

The EEG (Erneuerbare Energien Gesetz) rates for supply to the grid of electricity from geothermal generation should be kept at least at the current level.

To reduce prospecting risks, significant improvements in the basic data are required. Particularly important are comprehensive and systematic collection of underground temperature data and data on the hydraulic properties of the reservoirs. An »Atlas of geothermal electricity resources in Germany« should be drawn up with detailed information on local geological and geothermal conditions, and would fulfil an important requirement for realistic estimates of investment risks and hence decision-making on locations. Such activities to improve data availability should receive government support.

As there is always a prospecting risk when sinking the first wells at new locations, state guarantees for drilling risks should in particular be considered for the first demonstration projects.

Opportunities for state influence at the federal level on the process of realising greater contributions from geothermal heat-power cogeneration – particularly on the expansion of district heating grids – are entirely indirect in their nature. The task is to use promotion of technological developments, pilot and demonstration projects, guarantees for investment risks and securing revenue for electricity from geothermal generation to improve the conditions for such a process.

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