Global Geothermal Deployment – the IEA Roadmap for the Future

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Geothermal energy deployment is progressing rapidly in many countries around the world. In order to assist decision makers with future policy development and investment decisions, a Technology Roadmap for Geothermal Heat and Power, with deployment projections out to 2050, has recently been published by the IEA (2011). This publication was assisted by collaborating parties within the IEA-GIA (Geothermal Implementing Agreement) along with many other geothermal specialists, including members of the IGA, the IPGT, and lead authors of the geothermal chapter of the recently published IPCC special report on renewable energy (SRREN, Goldstein et al., 2011). The outcome of the deployment projections was that by 2050, geothermal would potentially contribute 3.4% of the global electricity (1400 TWh/yr) and 3.9% of the global heat demand (5.8 EJ/yr), thereby displacing significant equivalent CO_2 emissions from fossil fuel energy sources.

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Introduction

A geothermal roadmap was instigated by the IEA in response to requests from government leaders for more detailed analysis of the growth pathway for geothermal energy, and its potential to help mitigate global climate change effects through CO_2 emissions reduction. The purpose was to provide deployment projections and describe approaches and tasks regarding RD&D, financing mechanisms, legal and regulatory frameworks, public engagement and international collaboration. The roadmap evolved from several related and concurrent activities (e.g. IPCC-SRREN report) and was strongly supported by members of the IEA-GIA. It was also financially supported by the governments of Japan, the Netherlands, Switzerland, USA, and the IEA-GIA. Three workshops were convened (in Europe, USA and Indonesia) to provide as broad an input to the report as possible. In addition, numerous geothermal experts, from a wide range of companies and research organisations, willingly provided information and reviews. These individuals are acknowledged in the report.

Resource Types

Different types of geothermal resources have been identified as having potential for energy utilisation around the world. These include the conventional high temperature resources which make up the bulk of the 11 GW_e (~70 TWh/yr) of existing global geothermal power generation, and 15 GW_{th} (~223 PJ/yr) of non-GSHP direct-use applications.

Deep aquifer systems in porous and permeable formations are an under-utilised source of intermediate temperature fluids for heating and/or power production. Globally they consist mostly of hot saline brines in sedimentary basins, and constitute a widespread resource type of significant potential. Local energy demand, drilling cost, pumping cost, and flow-rates, are the parameters that mostly determine viability.

The future global technical potential for geothermal energy, from a theoretical perspective, is vast; some estimates suggest as much as 45 EJ/yr of power (12.5 PWh_e) and 1040 EJ/yr (289 PWh_{th}) of heat could be tapped within the terrestrial part of the upper 10 km of the earth's crust. This estimate excludes, however, advanced geothermal technologies that potentially could tap into additional off-shore hydrothermal systems, super-critical fluids, magmatic and geopressured resources. Any one of these could become a significant energy resource by the turn of the next century. Therefore, the limitations to accelerated global deployment are economic, rather than theoretical or technical potential.

Economics

Economics is the key driver behind regional geothermal deployment rates and investment. In some settings, for example in New Zealand, deployment is expected to increase rapidly over the next decade, potentially doubling local generation capacity, because the levelised cost of energy (LCOE ~US$50/MWh) for geothermal development is significantly lower than all alternative new generation options, despite relatively high capital costs (typically US$2-4M/$MW_e$), moderate operating costs (~2.5% of capital per annum), and the absence of subsidies (except for a carbon emissions trading scheme). In other settings, including Australia and most of Europe, additional economic incentives such as direct investment subsidies, feed-in tariffs, renewable portfolio standards, drilling risk insurance, grid access, or other policy instruments, are required to reduce exploration risks and accelerate early investment in geothermal. In addition, it is anticipated that the learning curve, a benefit of applied research, will gradually bring down the cost in real terms.

Important Findings

The roadmap document shows that future base-load power and heat can be provided by a variety of renewable geothermal energy resources. These include hydrothermal resources and deep aquifer systems at a wide range of temperatures, and hot rock resources which are fractured or stimulated for energy extraction using fluids. The roadmap envisages deployment of geothermal heat and power by several different means.

In the period to 2030, rapid expansion of geothermal electricity and heat production will be dominated by accelerated deployment of conventional high-temperature hydrothermal resources, driven by relatively attractive economics in areas where such resources are available. Deployment of low- and medium-temperature hydrothermal resources in deep aquifers will also grow quickly, reflecting wider availability and increasing interest in their use for both heat and power.

By 2050, geothermal electricity generation could reach 1400 TWh per year, that is, about *3.5%* of global electricity production. Geothermal heat (not including ground source heat pumps) could contribute 5.8 EJ (1600 TWh thermal energy) per year by 2050, about 3.9% of global heat demand.

About *5*0% of the projected increase by 2050 comes from hot rock resources developed as enhanced geothermal systems (EGS). Greater research, development and demonstration resources are needed in the next two decades to ensure EGS becomes commercially viable by 2030.

To achieve this deployment, policy frameworks are needed that address technical barriers related to resource assessment, accessing and engineering the resource, geothermal heat use and advanced geothermal technologies. Frameworks are also needed to deal with barriers related to economics, regulations, market facilitation and RD&D support. Policy makers, local authorities and utilities need to be more aware of the full range of geothermal resources available and of their possible applications. This is particularly true for geothermal heat, which can be used at a range of temperatures for a wide variety of tasks.

Important R&D priorities for geothermal energy include accelerating resource assessment, developing more competitive drilling technology and improving EGS technology, as well as managing environmental concerns.

Advanced technologies for offshore, geo-pressured and super-critical (including magma) resources could unlock a huge additional resource base. Co-produced hot water from oil and gas wells could also be utilised economically.

Key Short-Term Actions

Establish medium-term targets for mature and nearly-mature technologies, and long-term targets for advanced technologies; thereby increasing investor confidence and accelerating expansion of geothermal heat and power.

Introduce economic incentive schemes for both geothermal heat (which has received less attention to date) and geothermal power, with incentives phasing out as technologies reach full competitiveness.

Develop publicly available databases, protocols and tools for geothermal resource assessment and reservoir management to help spread expertise and accelerate development.

Introduce streamlined and efficient procedures for issuing permits for geothermal development.

Provide funds for sustained and substantially higher research, development and demonstration (RD&D) activities to plan and develop at least 50 more EGS pilot plants during the next 10 years.

Expand and disseminate information on EGS technology to enhance production, sustainable resource utilization, and management of environmental performance.

In developing countries, expand the efforts of multilateral and bilateral aid organisations to develop rapidly the most attractive available hydrothermal resources, by addressing economic and non-economic barriers.

Summary

Geothermal energy deployment is progressing rapidly in many countries and has significant potential for greater, widespread development. In order to assist future decision makers, a Technology Roadmap for Geothermal Heat and Power, with global deployment projections, has recently been published by the IEA, with the assistance of the IEA-GIA. The Roadmap envisages geothermal contributing about 3.4% of global electricity needs, and 3.9% of global heating demand, by 2050, displacing equivalent fossil-fuel CO_2 emissions. For more information on the document, contact Milou Beerepoot, Renewable Energy Division, IEA, Paris Headquarters, (Milou.Beerepoot@IEA.org).

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