STATUS, DEVELOPMENT, AND PROSPECTS OF GEOTHERMAL ENERGY

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- Basis of geothermal energy utilization
- Geothermal energy within the renewables
- Power generation and direct use
- Sustainability and economics
- Future prospects, combating climate change

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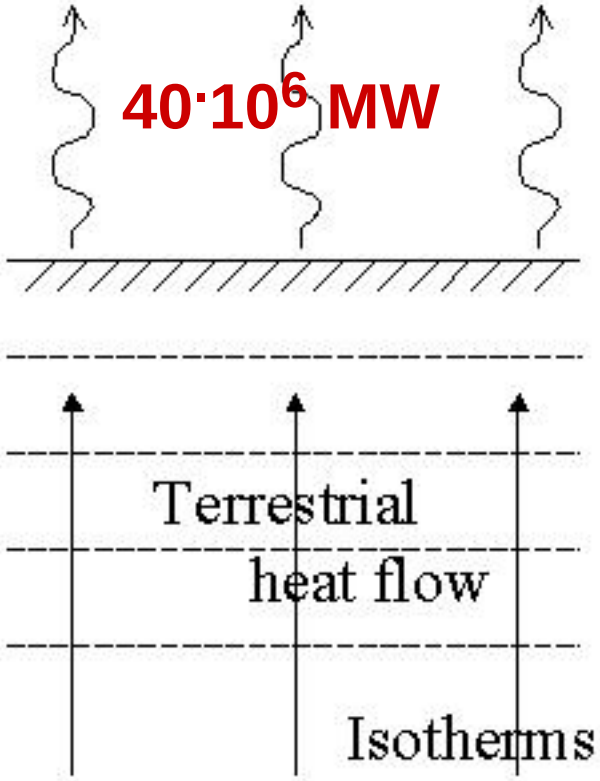
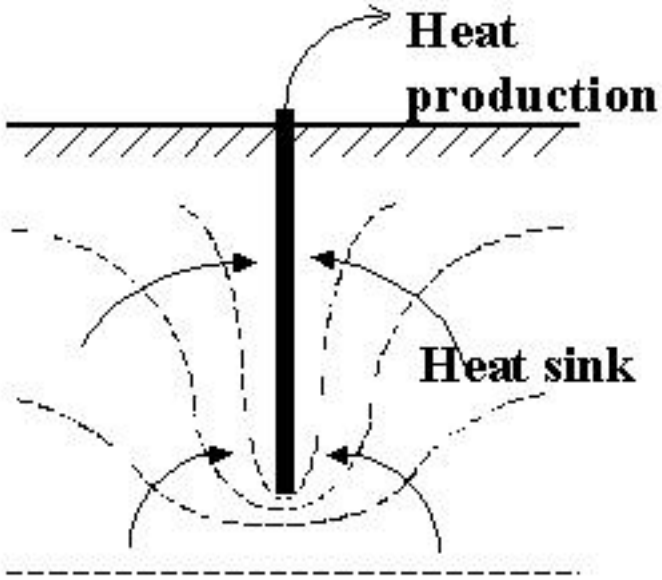


The terrestrial heat flow is lost to the atmosphere



The heat sink captures the heat flow

Principle of geothermal energy utilization: collecting earth's heat.

Electricity from renewable sources in 2005.

Compiled from Tables in 2007 Survey of Energy Resources (WEC, 2007)

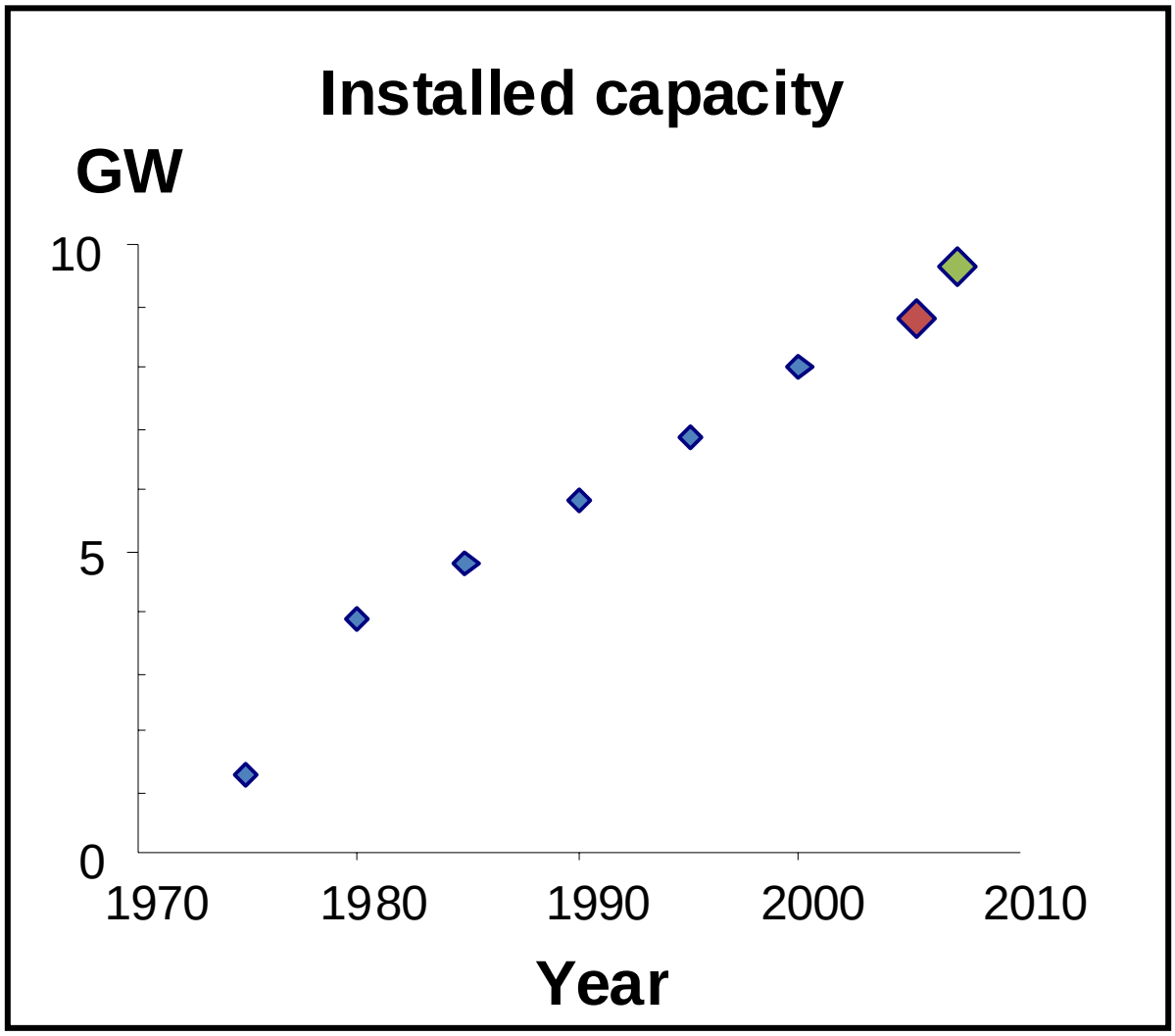
Technology	Installed capacity		Production per year		Availability factor %
	GWe	%	TWh/yr	%	
Hydro	778	87.5	2,837	89	42
Biomass	40	4.5	183	5.7	52
Wind	94* 59	6.6	106	3.3	21
Geothermal	10* 9	1.0	57	1.8	72
Solar	9.1** 4	0.4	5	0.2	14
Total	**890**	**100**	**3'188**	**100**	**41***

*) in 2008

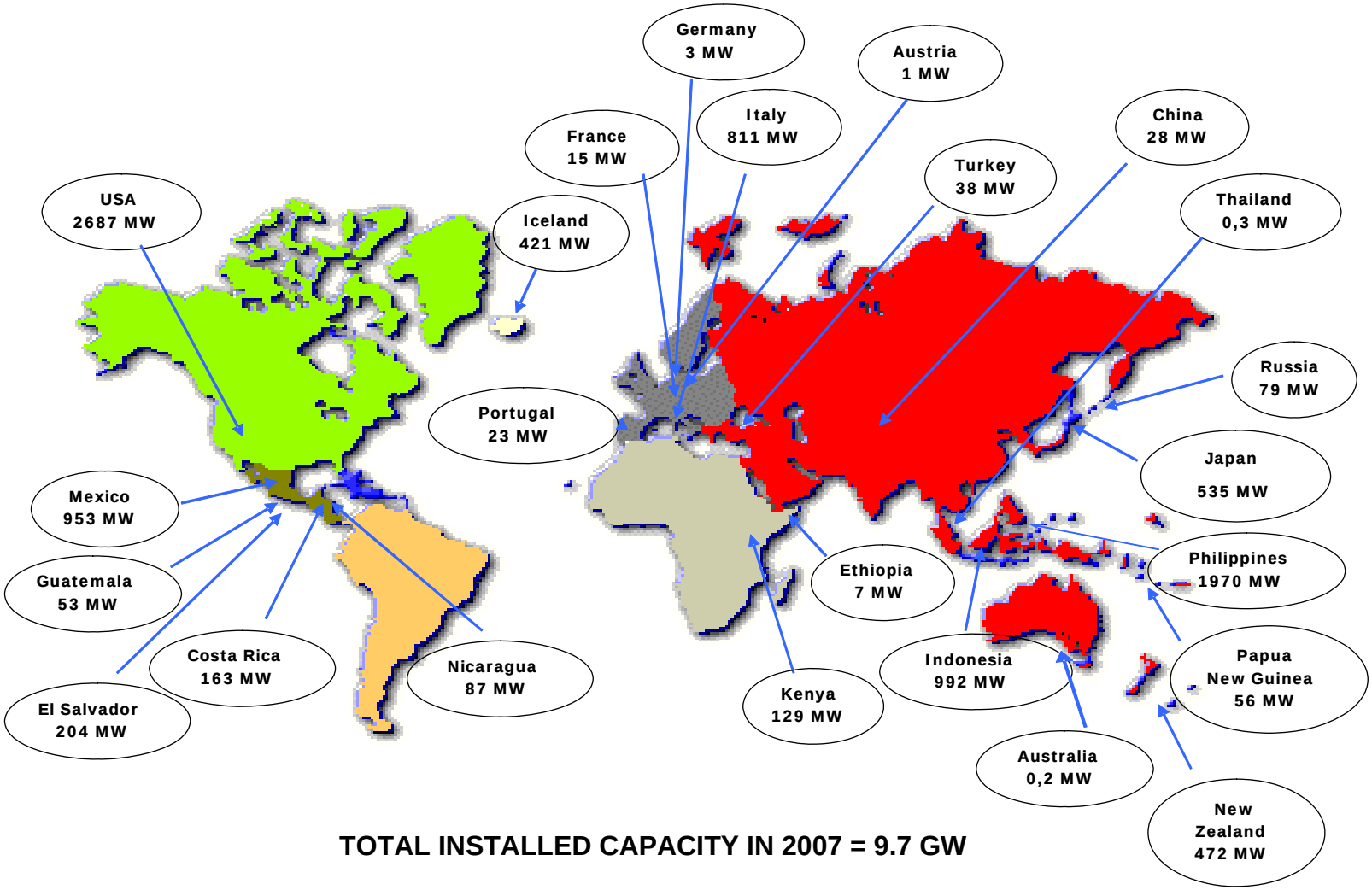
**) new in 2007: 2.8 GW

*) weighted average

Geothermal energy is available round around the clock all year. Providing 1.8% of global renewable electricity with only 1% of the installed capacity reflects the reliability of geothermal plants, which can be operated at availability factors in excess of 80%,



Installed capacity for electricity production from 1975 up to end of 2007 (red) and forecast to 2010 (green) *(Bertani, 2007).*



Geothermal power plant capacities in 2007 in different countries.
(from Bertani, 2007).

12 MWe (3x4) - 1999

7 plants

73 MWe

By 2010

300 MWe

1st stage 50 MWe (2x25)

Separators – 50 MWe

Severe weather - unmanned and remote controlled – planned

15 m snow

Turbines – 50 MWe

Mutnovsky power plant, Kamchatka, Russia

Geothermal direct use

Direct application of geothermal energy is being realized in a vide variety of uses: space heating, industrial and agriculture applications, spas and wellness facilities. Direct use is reported from 72 countries.

The worldwide direct use of geothermal heat is currently about 300 PJ/yr, produced by a total capacity of about 30 GW_{th}.

The usage is distributed as follows: space heating 52% (thereof 32% using heat pumps), bathing and swimming (including balneology) 30%, horticulture (greenhouses and soil heating) 8%, industry 4%, and aquaculture (mainly fish farming) 4% .

Top fifteen countries utilising geothermal energy in 2005.

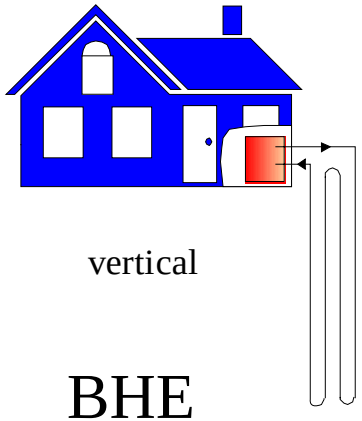
Data on electricity from Bertani (2005) and on direct use from Lund et al. (2005).

Geothermal electricity production		Geothermal direct use	
	GWh/yr		**GWh/yr**
USA	17,917	China	12,605
Philippines	9,253	Sweden	10,000
Mexico	6,282	USA	8,678
Indonesia	6,085	Turkey	6,900
Italy	5,340	Iceland	6,806
Japan	3,467	Japan	2,862
New Zealand	2,774	Hungary	2,206
Iceland	1,483	Italy	2,098
Costa Rica	1,145	New Zealand	1,968
Kenya	1,088	Brazil	1,840
El Salvador	967	Georgia	1,752
Nicaragua	271	Russia	1,707
Guatemala	212	France	1,443
Turkey	105	Denmark	1,222
Guadeloupe (France)	102	Switzerland	1,175

Geothermal heat pumps

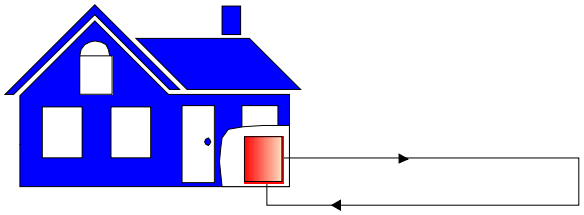
The highest growth rate in direct use is with geothermal heat pumps (GHP), one of the fastest growing renewable energy technologies.

World-wide production by GHPs increases (in PJ/yr): 14.6 in 1995, 23.3 in 2000, 87.5 in 2005. GHPs provide space heating, cooling and also domestic hot water.



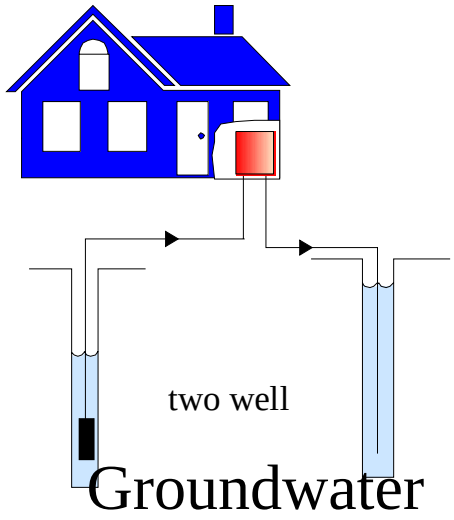
vertical

BHE



horizontal

Red: heat pump



two well

Groundwater

Geothermal sustainability

Geothermal energy is generally classified as a renewable resource, where “renewable” describes a characteristic of the resource: the energy removed from the resource is continuously replaced on time scales similar to those required for energy removal. Consequently, geothermal production is not a “mining” process.

Geothermal energy can be used in a “sustainable” manner, which means that the production system applied is able to sustain the production level over long times.

The longevity of production can be secured and sustainable production achieved by using moderate production rates, which take into account the local resource characteristics (field size, natural recharge rate, etc.).

Economics

Electricity production cost from renewables (WEA, 2004)

Power plant type	Generation cost (US cent/kWh)
Hydro	2 – 10
Geothermal	2 – 10
Wind	4 – 8
Biomass	3 – 12
Solar PV	25 – 160
Concentrated solar	12 – 34

Currently the installation cost of geothermal power plants is around 3.0 – 4.5 million €/MWe, the production cost 40 – 100 €/MWh. CO_2 taxing and feed-in tariffs will help in the future.

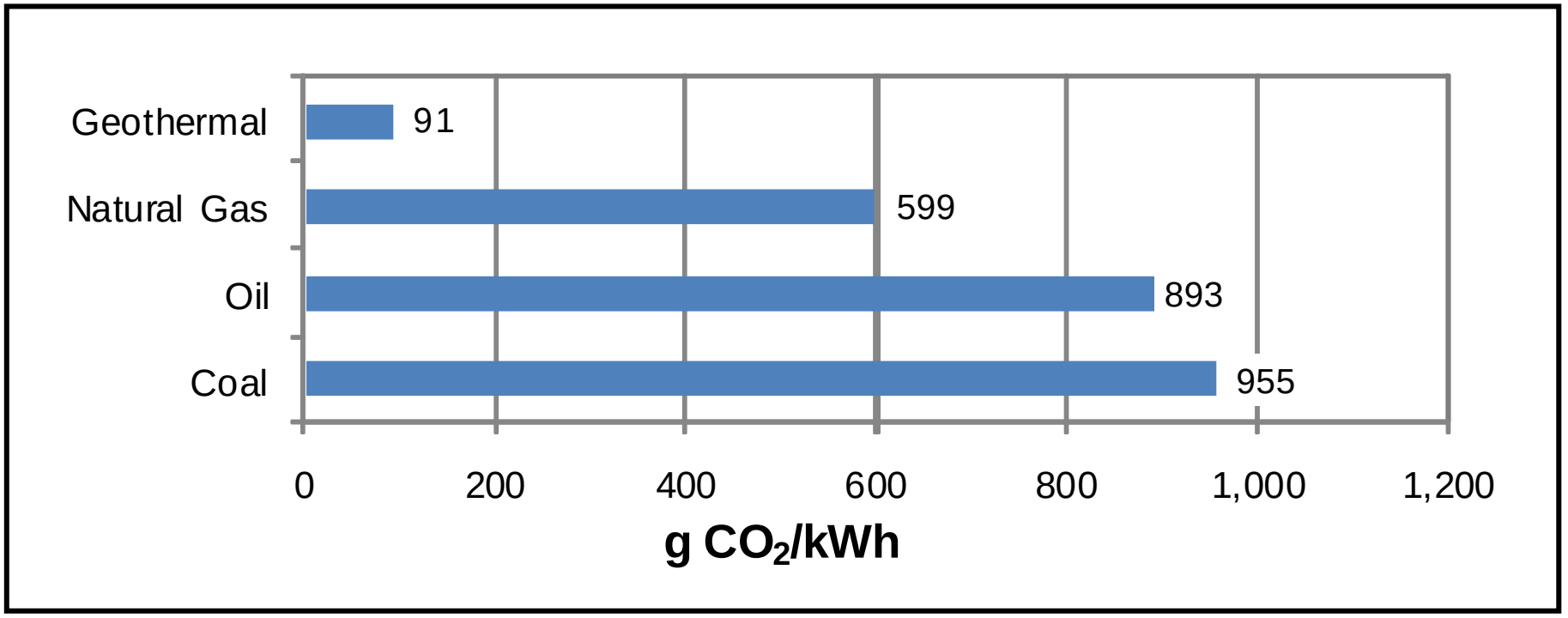
Direct use average unit cost of heat for geothermal district heating is 2.0 €/GJ. For geothermal heat pumps the cost of combined heating/cooling is 16.0 €/J; return of investment time is in 4 – 8 years for GHPs.

Future prospects, combating climate change

Geothermal technologies cause little or no greenhouse gas emissions since no burning processes are involved. Power generation as well as direct use already contribute to the reduction of CO_2 emissions. Further deployment – depending on future growth rates – cold reduce CO_2 emissions even more significantly.

Quantitative development trends for coming decades can only be estimated. It is considered possible to increase the installed world geothermal electricity capacity from the current 10 GW to 70 GW with present technology, and to 140 GW with enhanced technology until 2050.

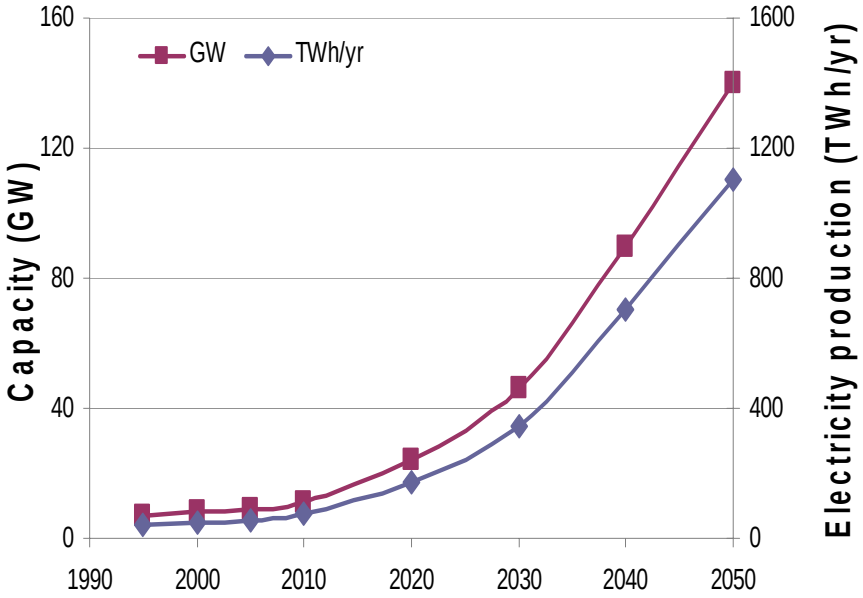
Production from direct use in 2050 has been estimated at 5.1 EJ/yr, with the GHP portion at 4.2 EJ/yr.

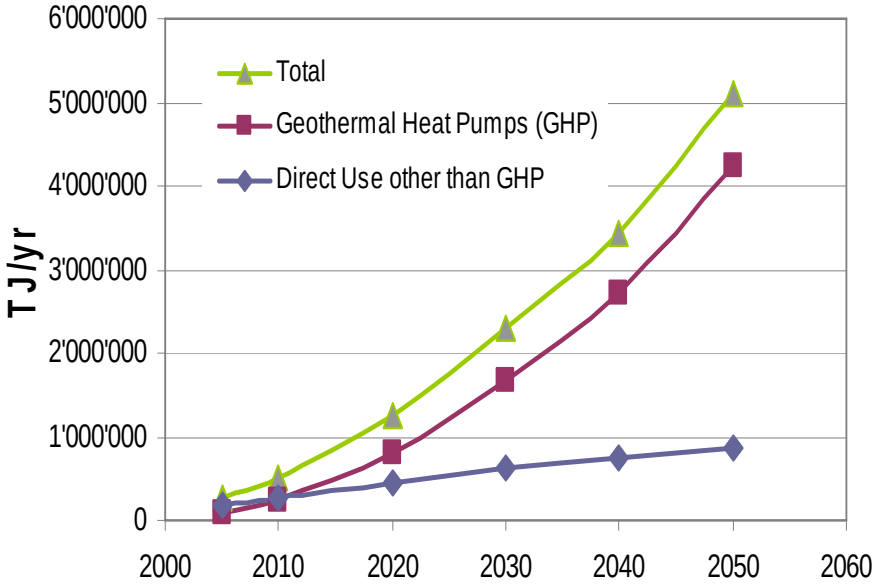


Comparison of CO_2 emission from electricity generation from different energy sources in the USA.

Data from Bloomfield et al. (2003).

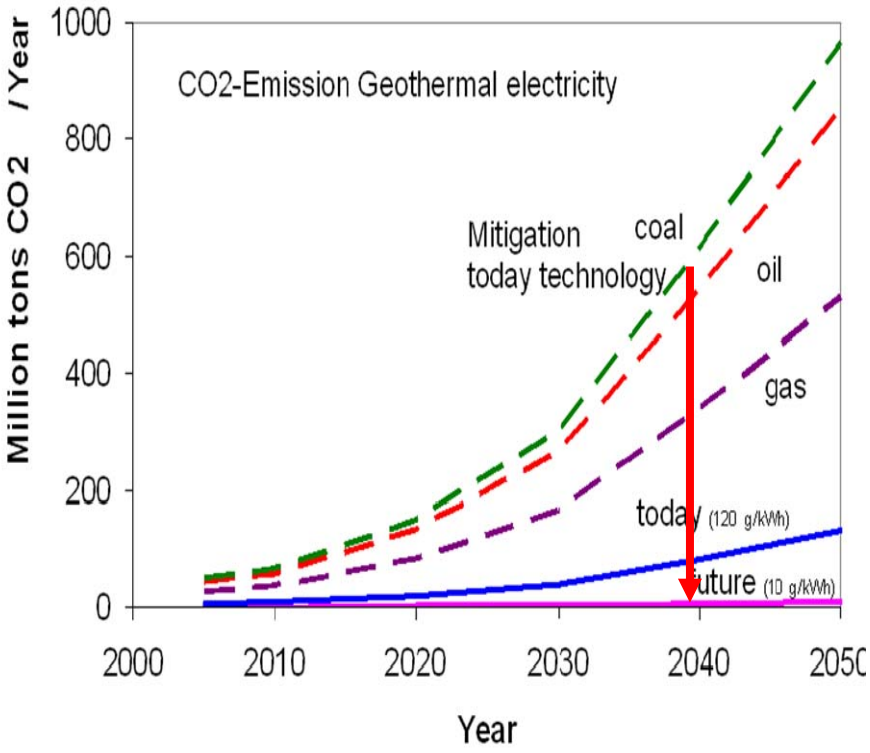
Global growth scenarios

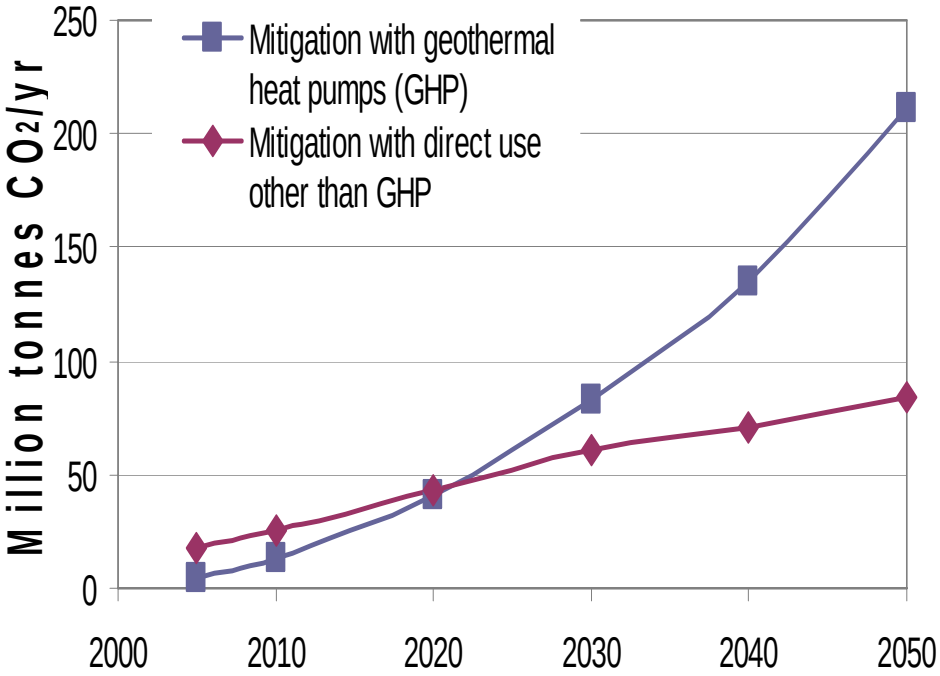




Projection of geothermal power development (left); projection of direct use heat production (right) to 2050.
From Fridleifsson et al. (2008).

Geothermal CO_2 emission mitigation potential

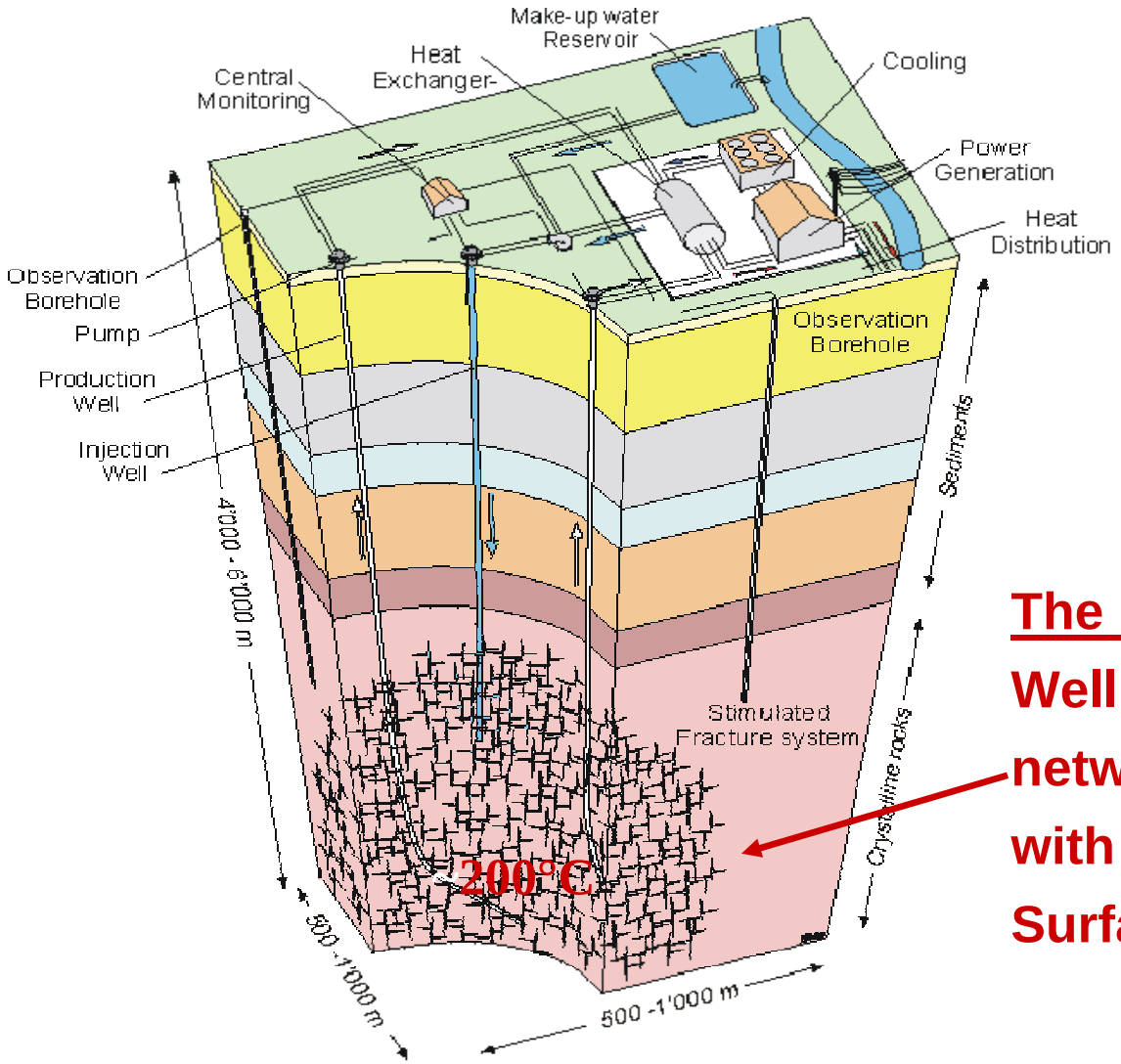




Left: **Mitigation potential of geothermal power plants in the world –when replacing fossil technologies–**

Right: **Mitigation potential of geothermal direct heating use in the world, based on the growth estimate data.**

The future :EGS for cogeneration (combined heat / power)



Concept of the Deep Heat Mining System

<u>The main component</u>:

Well distributed fracture network at several km depth with sufficient heat exchange Surface.

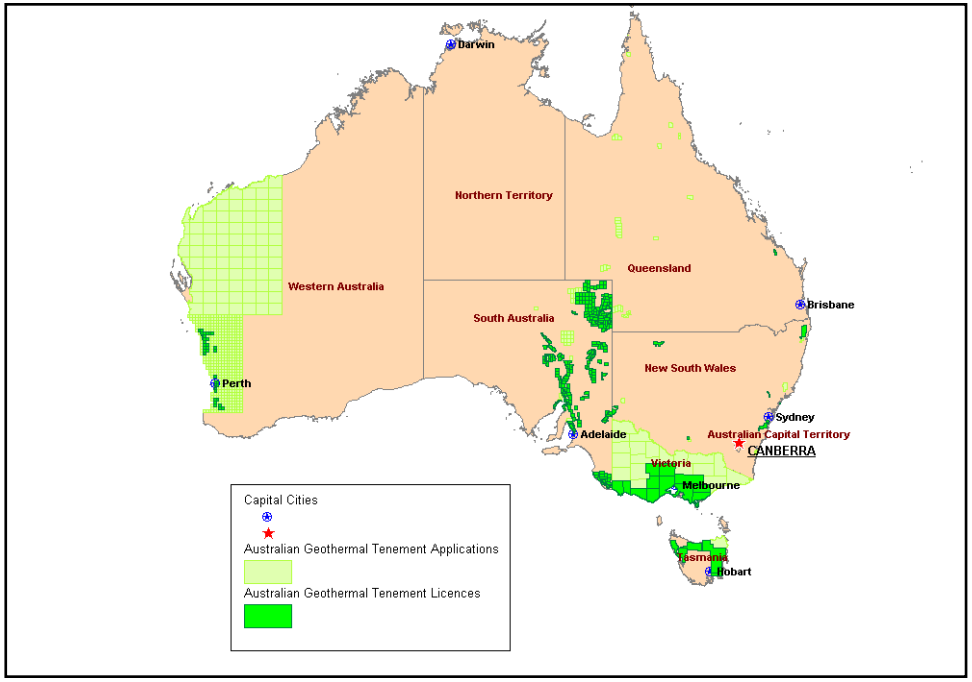
EGS potential

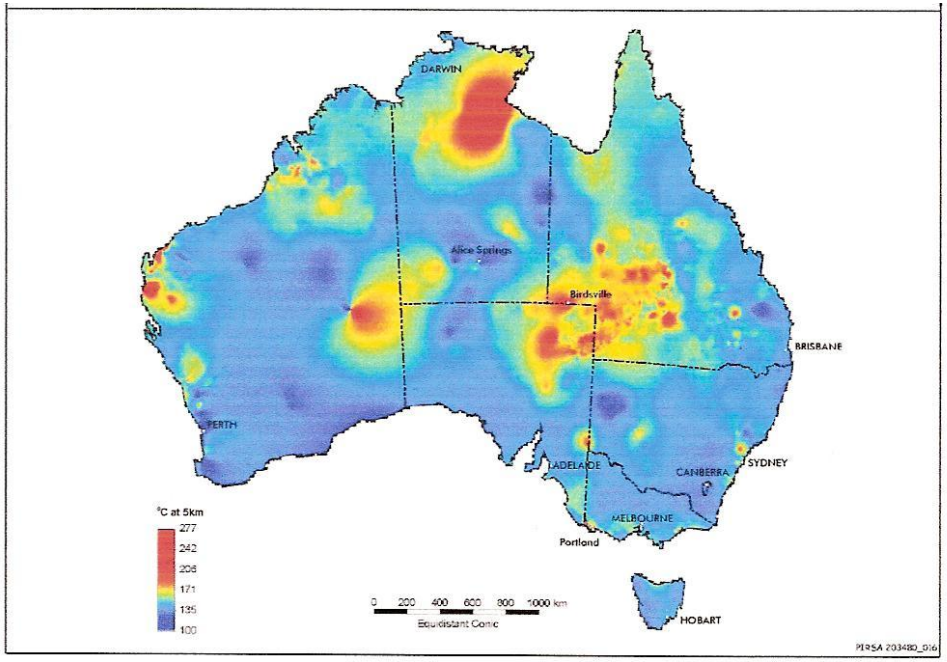
The EGS potential is huge: A recent M.I.T. study determined for the USA alone recoverable resources > 200,000 EJ, corresponding to 2,000 times the annual primary energy demand.

Current EGS status

After internationally organized EGS research over about 25 years the first EGS power plant is now producing electricity with 1.5 MWe capacity at Soultz-sous-Forêts/France.

In Australia there is a veritable EGS boom (numerous stockmarket-registered enterprises), newly also in the USA. Nevertheless some basic questions still need answers.





Distribution of geothermal development licences in Australia

Selection criteria:

High heat flow /HHP granites

Source: G. Beardsmore, P. Chopra

Remaining R&D needs

Development of a technology to produce electricity and/or heat from a basically ubiquitous resource, in a manner relatively independent of site conditions.

There is no experience about possible changes of an EGS heat exchanger with time

So far the envisaged electric power capacity of EGS systems is limited at a few MWe. But in order to play a significant role in electricity supply a system capacity of at least several tens of MWe would be essential.

One of the main future R&D goals will be to see whether and how the EGS power plant size could be upscaled,

Conclusions

The basis of geothermal energy is the immense heat content of the earth's interior; since billions of years it is constantly supplied by the decay of natural radioisotopes. Thus the resource is vast and ubiquitous and has a correspondingly large potential for utilization.

The two main lines of geothermal energy utilization, power generation and direct use, are currently producing about 60 TWh_e with 10 GW_e power, and about 300 TJ/yr with 30 GW_{th} and are constantly growing, to 70 GW_e with present technology, and to 140 GW_e with enhanced technology until 2050. Production from direct use in 2050 has been estimated at 5.1 EJ/yr, with the geothermal heat pump portion at 4.2 EJ/yr.

Power generation as well as direct use already contribute to the reduction of CO_2 emissions. Further deployment, – depending on future growth rates – could reduce CO_2 emissions even more significantly.

World Geothermal Congress 2010

Geothermal: „The Energy to Change the World“

25- 29 April 2010, International Conference Center, Nusa Dua-Bali, Indonesia

Bali, Indonesia
25 - 29 April 2010

http://www.wgc2010.org/

Welcome to the World Geothermal Congress (WGC) 2010 – Bali Website

The World Geothermal Congress 2010 (WGC2010) - Geothermal powering world's today energy, will take place in Bali Indonesia at the Bali International Conference Center (BICC), Nusa Dua, Bali's largest conference venue, named top in the category "World's leading Conference & Convention Centre 2006". Over 3000 participants from more than 80 countries are expected to attend and learn about the latest breakthroughs in the field. An Exhibition, held simultaneously with the Conference, will feature foremost companies and state-of-the-art products of the Geothermal industry

Co - Convened by:

International Geothermal Association (IGA)

Indonesian Geothermal Association (INAGA)

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