

# SUSTAINABLE GEOTHERMAL PRODUCTION AND CO<sub>2</sub> EMISSION REDUCTION

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- **Introduction**
- **Geothermal sustainability (definition, examples)**
- **CO<sub>2</sub> emission issues and mitigation options (at the example of geothermal heat pumps)**
- **Conclusions**



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# SUSTAINABILITY

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**The original definition of sustainability goes back to the Bruntland Commission (1987; reinforced at the Rio 1991, Kyoto 1997 and Johannesburg 2002 UN Summits):**

*„Meeting the needs of the present generation without compromising the needs of future generations“*

# **Geothermal sustainability**

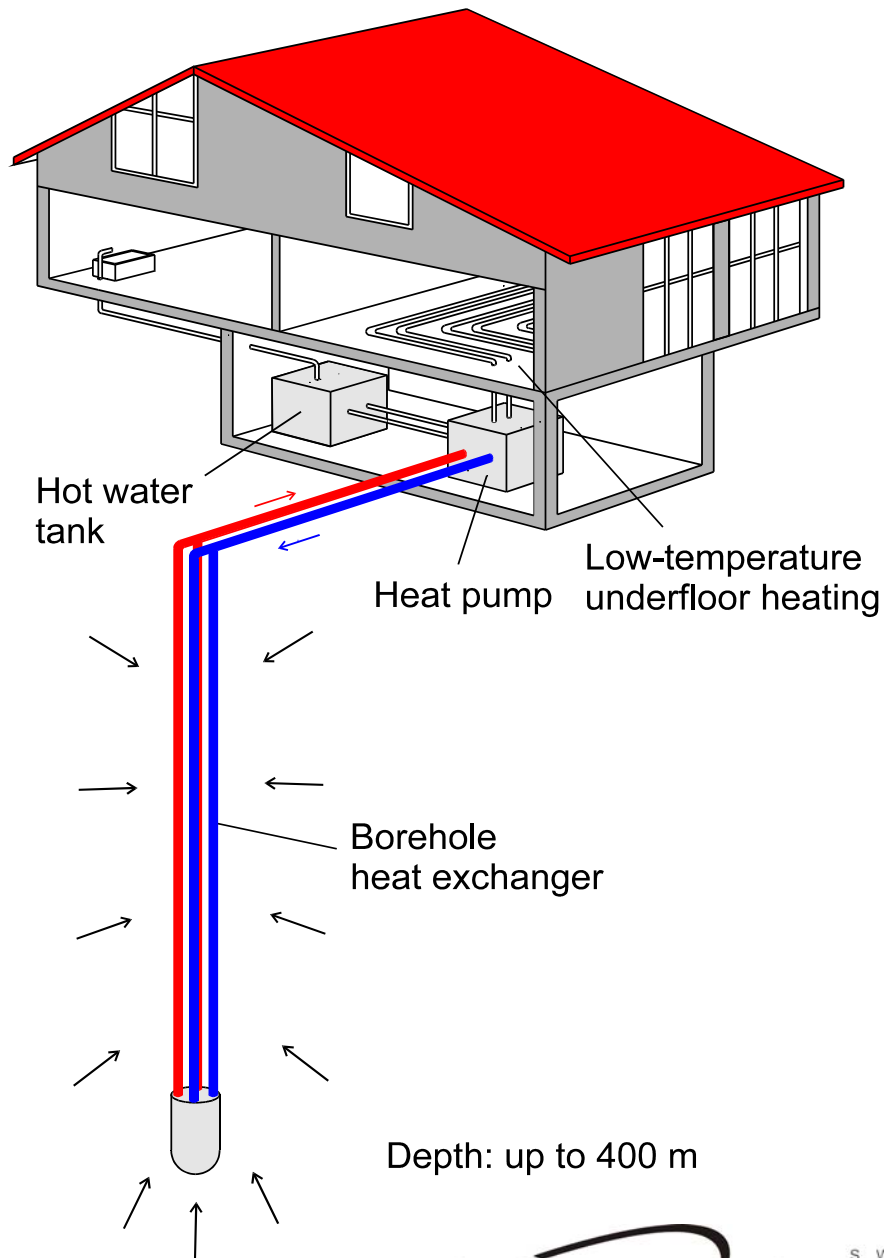
**Geothermal energy is generally classified as a renewable resource, where “renewable” describes a characteristic of the resource: the energy removed from the resource is continuously replaced on time scales similar to those required for energy removal. Consequently, geothermal production is not a “mining”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

## The good news:

- The production of geothermal fluid and/or heat successively creates a hydraulic/heat sink in the reservoir.
- This leads to pressure and temperature gradients which in turn –after termination of production– generate fluid/heat inflow to re-establish the pre-production state.



**Schematics of a geothermal heat pump system with borehole heat exchanger (BHE)**

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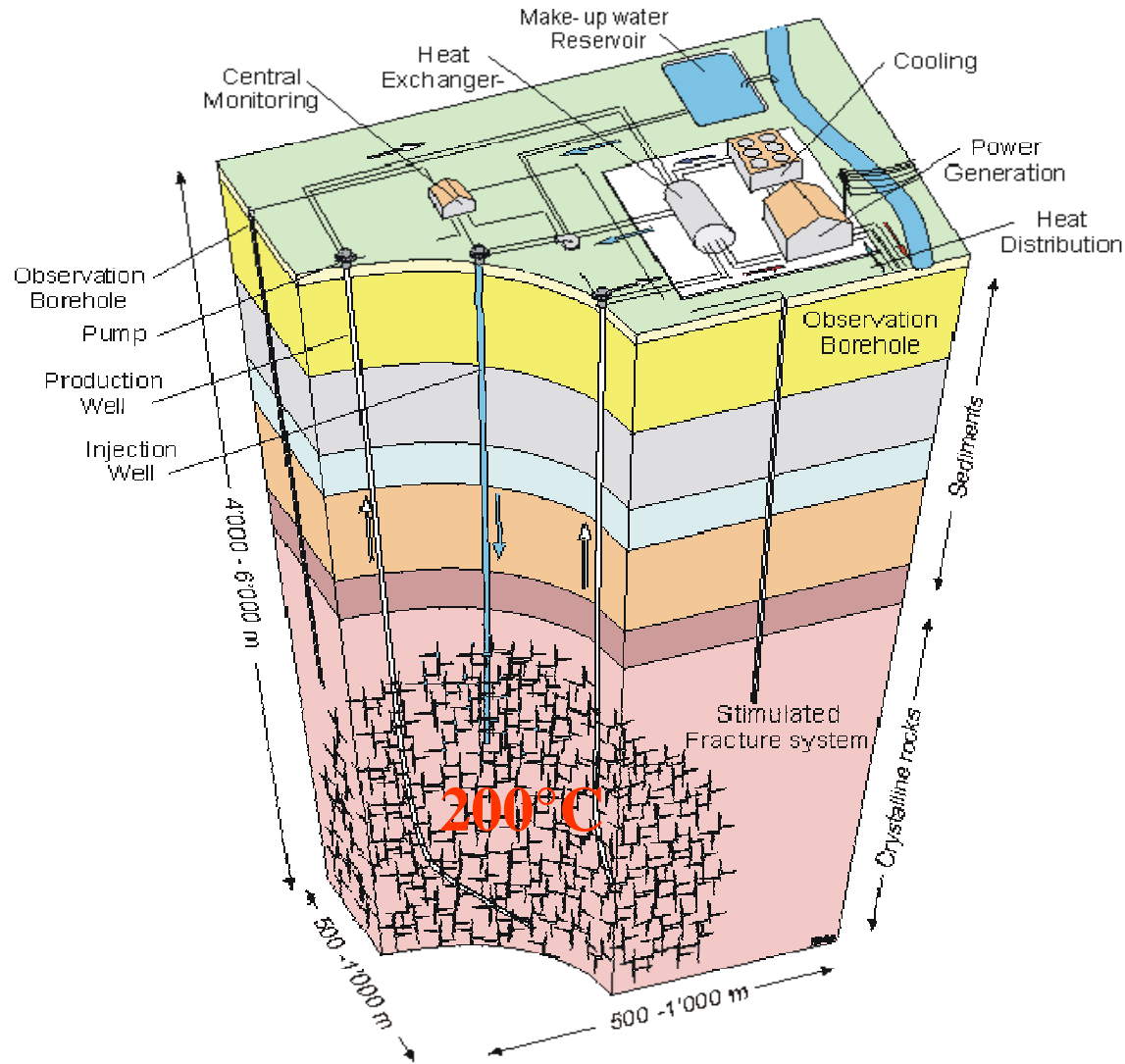
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## THE KEY ISSUE: THE SUSTAINABLE PRODUCTION LEVEL

With high geothermal production (fluid/heat) extraction rates the energy yield will be correspondingly high at the beginning (and with it the economic reward) but the energy delivery will decrease significantly with time, and can cause the breakdown of a commercially feasible operation.

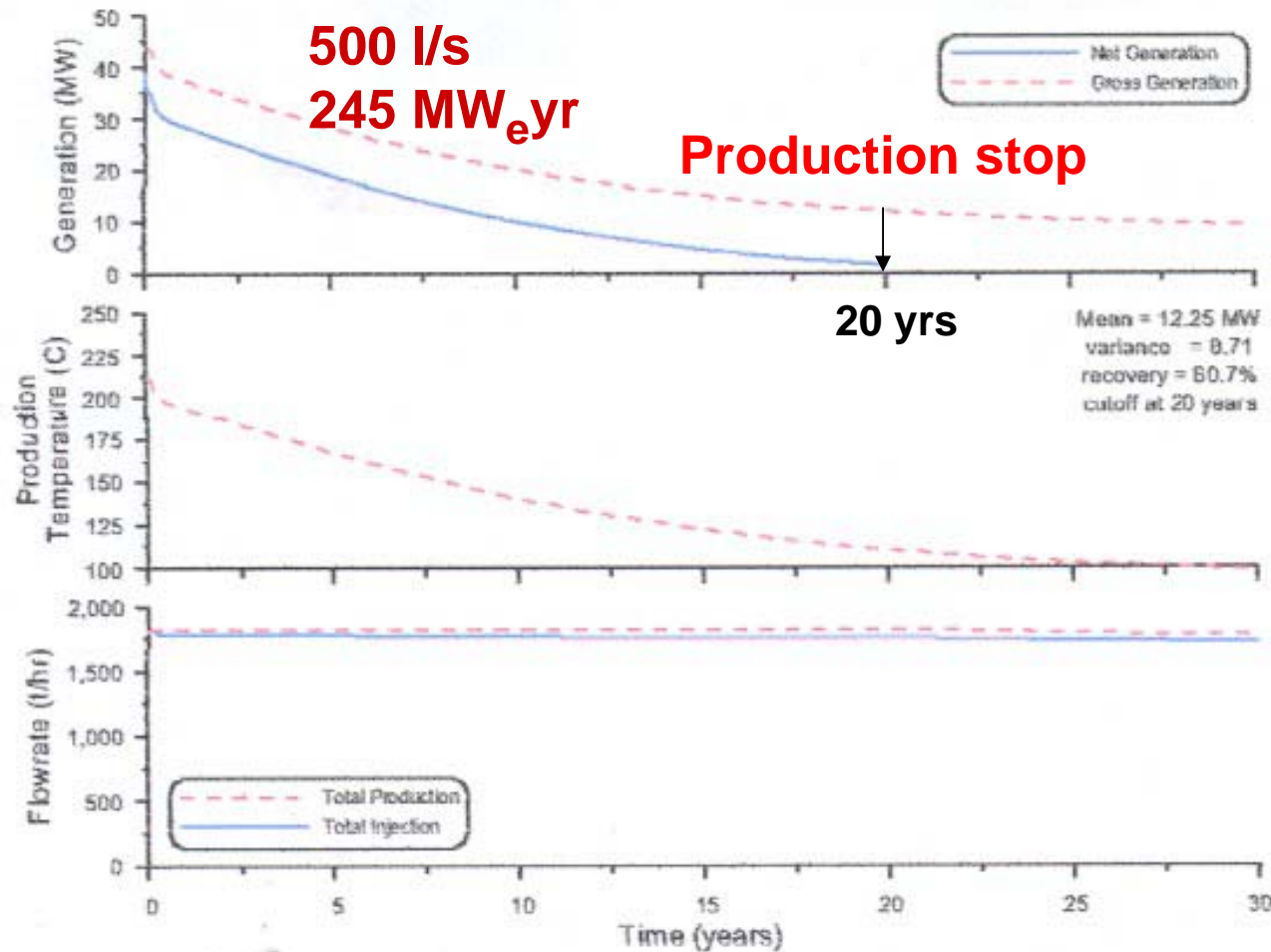
Lower production rates can secure the longevity of production, i.e. relatively constant production rates can be sustained. In addition, an EGS example described below shows that sustainable production rates can provide similar total energy yields to those achieved with high extraction rates.

# HDR / EGS scheme



Concept of the Deep Heat Mining System

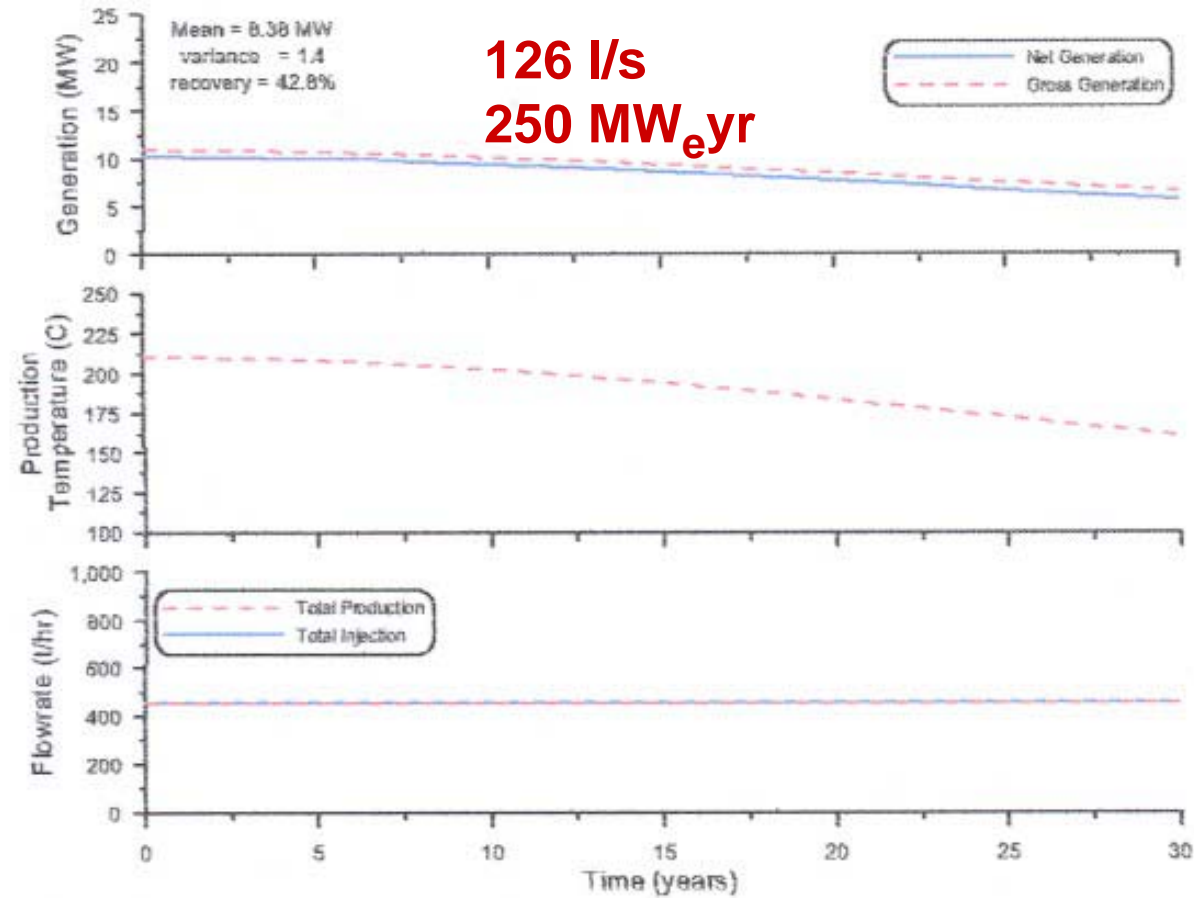
## Long-term effects



**With high circulation rate (500 l/s) production starts at 45 MW<sub>e</sub> capacity but terminates after 20 years; total generation: 245 MW<sub>e</sub>years.**

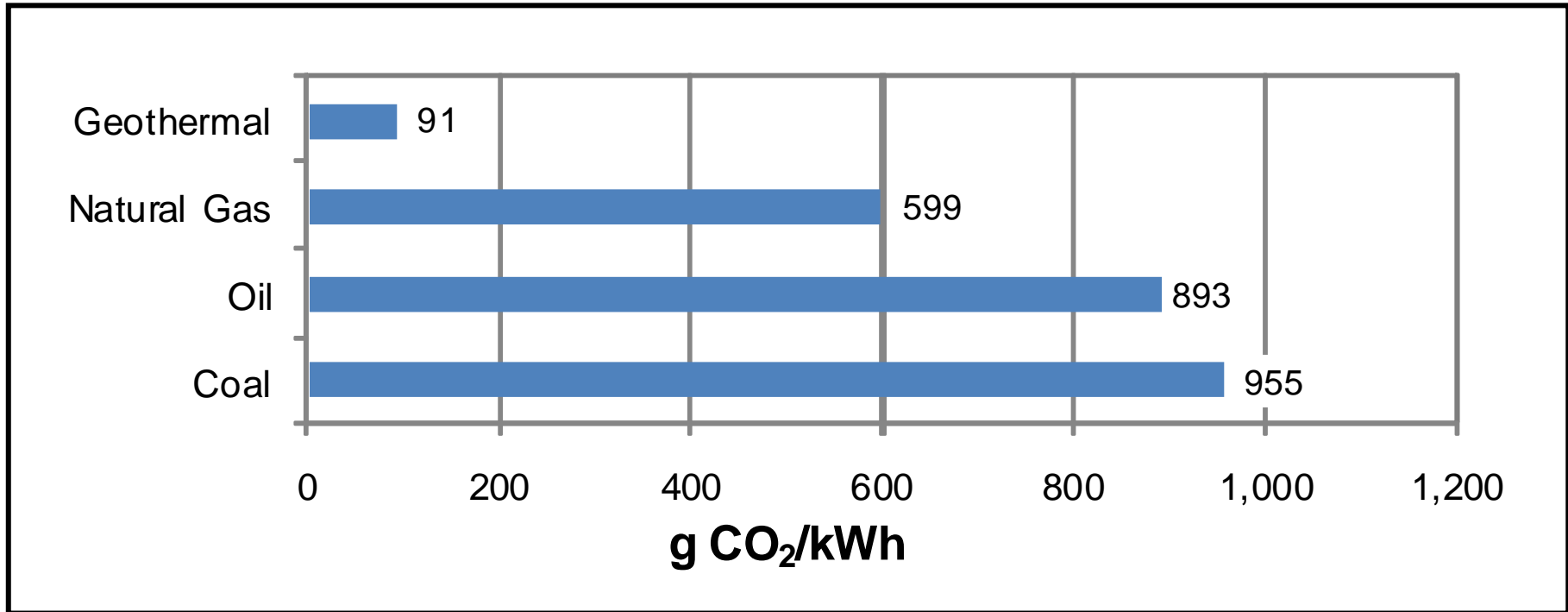
**(from Sanyal & Butler 2005)**





**Lower circulation rate (126 l/s) yields sustainable, long-lasting power production; total generation comparable ! (250 MW<sub>e</sub>years)**

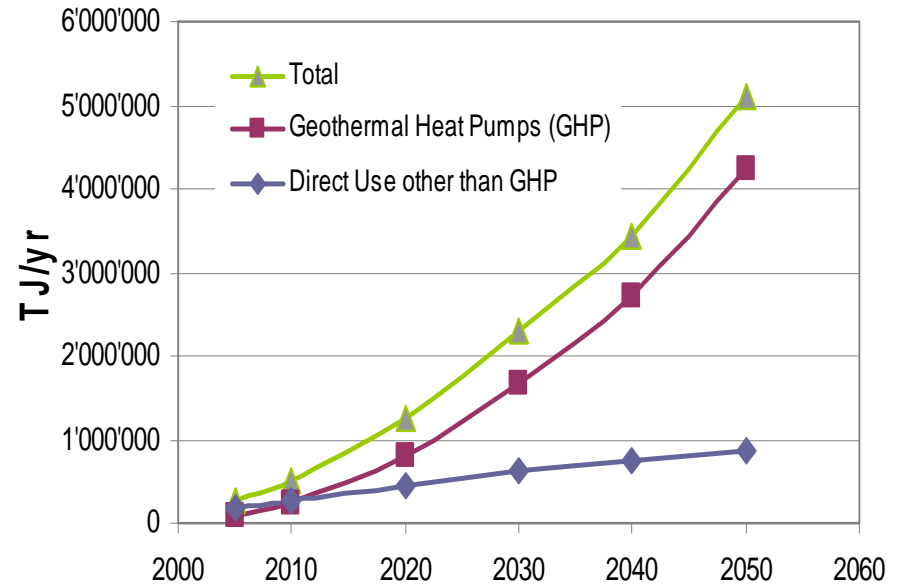
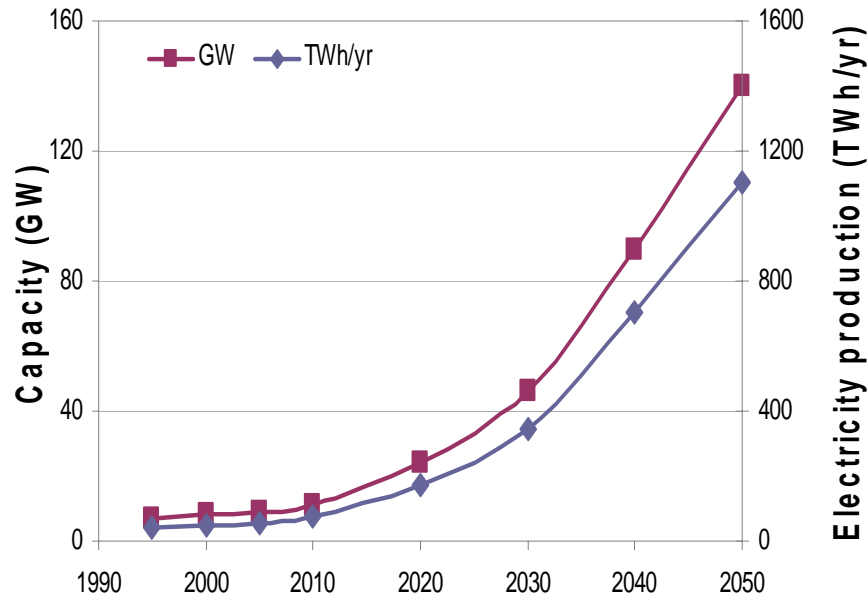
**(from Sanyal & Butler 2005)**



**Comparison of CO<sub>2</sub> emission from electricity generation from different energy sources in the USA.**

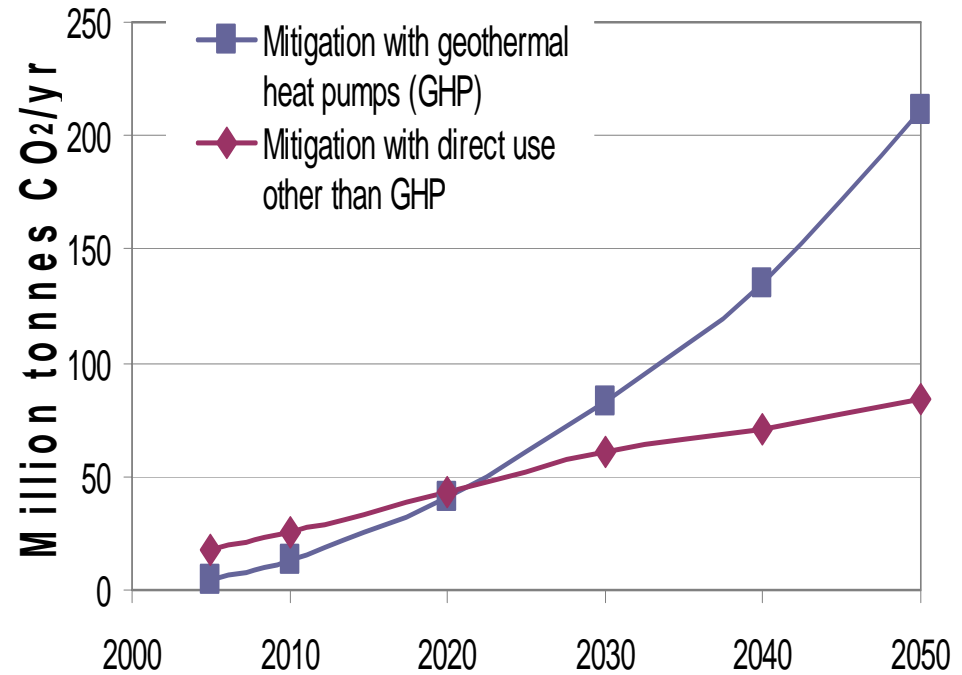
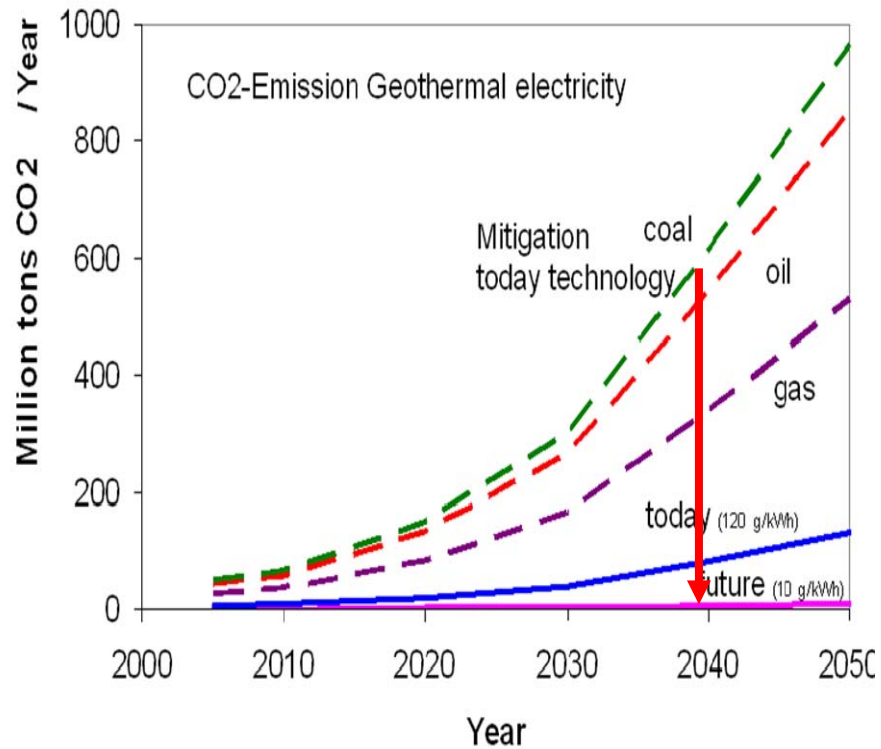
*Data from Bloomfield et al. (2003).*

# Global growth scenarios



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

# Global geothermal CO<sub>2</sub> 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.

## **CONCLUSIONS – SUSTAINABILITY**

**Geothermal resources can be considered renewable on time-scales of technological/societal systems, and do not need geological times as fossil fuel reserves do (coal, oil, gas).**

**Unlike for mining (e.g. mining out an ore body), there will be geothermal resource regeneration. The recovery typically shows asymptotic behaviour, being strong at the beginning and slowing down subsequently.**

**For geothermal energy utilization, sustainability means the ability of the production system applied to sustain the production level over long times. Sustainable production of geothermal energy therefore secures the longevity of the resource, at a lower production level.**

**Sustainable production secures the longevity of the resource at a lower production levels; the level of sustainable production depends on the utilization technology as well as on the geothermal resource characteristics; production from geothermal resources should be limited to sustainable levels.**

## **CONCLUSIONS – CO<sub>2</sub> EMISSION AVOIDANCE**

**Geothermal technologies produce little or no greenhouse gas emissions since no burning processes are involved.**

**Geothermal development estimates for 2050 indicate that power generation could mitigate CO<sub>2</sub> emissions by 100's of Mt/yr, direct use >1500 Mt/yr, most of it by geothermal heat pumps. These need electricity, its source must be considered.**

**Real CO<sub>2</sub> emission reduction can only be achieved when an “old” air-conditioning system fed by “dirty” electricity gets replaced by geothermal heat pumps, i.e. in renovation.**

**When complemented by measures in improved construction solutions like efficient thermal isolation to reduce the energy consumption of buildings, the heat pump systems to provide space heating, cooling and domestic hot water can and will contribute in the future significantly to avoid and to reduce CO<sub>2</sub> emissions.**



***Many thanks for your attention !***

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