Iceland Liechtenstein Norway grants

Norway grants

Geothermal energy – general introduction

Improving the energy efficiency of geothermal energy utilisation by adjusting the user characteristic

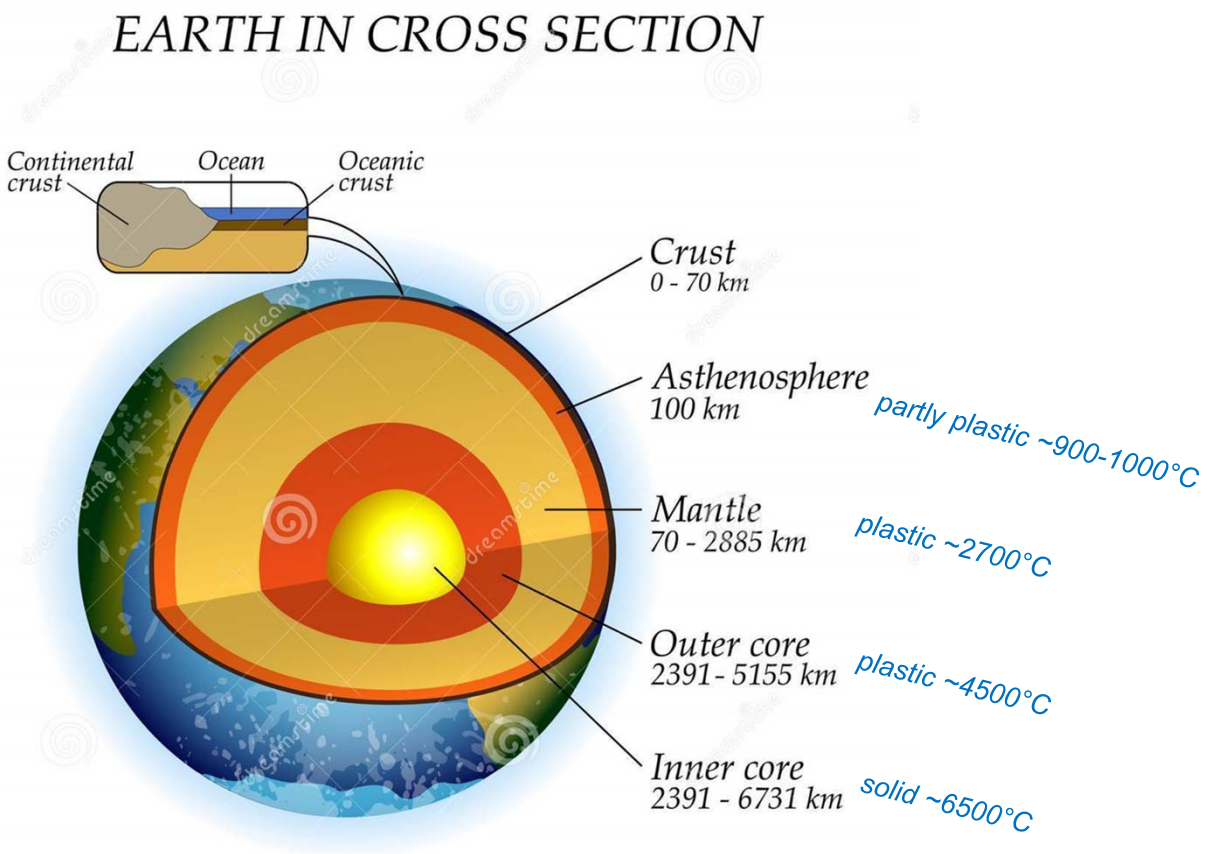
User4GeoEnergy

Annual Seminar 2021
Round table

13:45 – 13:55 The introduction to geothermal energy

07.12.2021

Geothermal energy



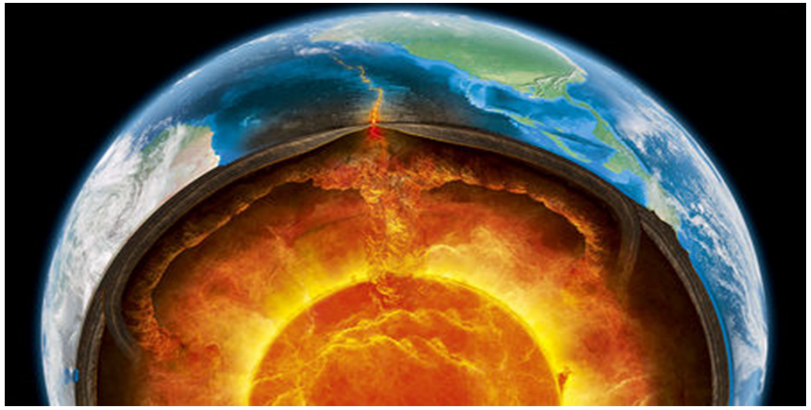
Source: https://pl.dreamstime.com/struktura-ziemia-w-przekroju-poprzecznym-warstwy-sedno-salopa-asthenosphere-szablon-dla-edukaci-wektor-image103704278

Geothermal energy *Geothermal.*

Energy in the form of natural heat flowing outward from within the earth and contained in rocks, water, brines, or steam.

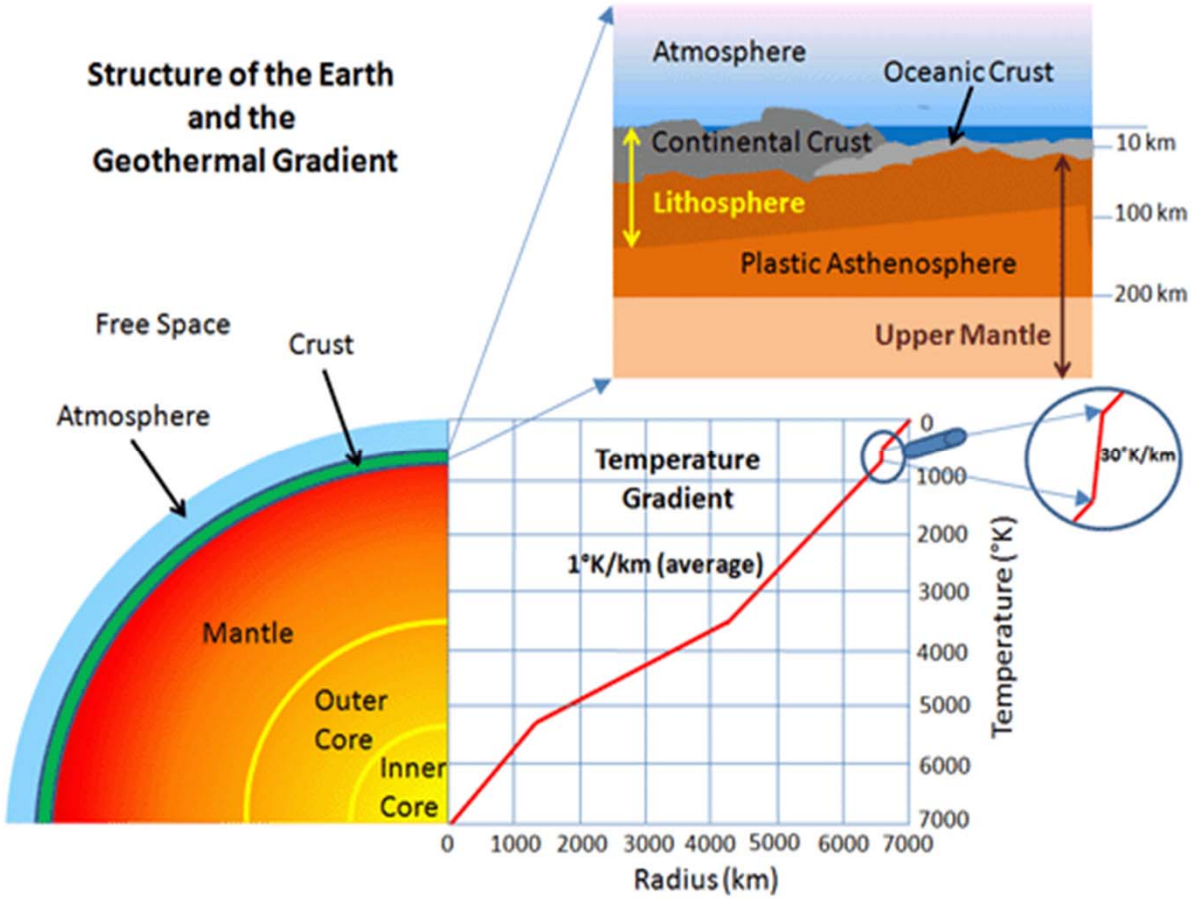
This heat is produced mainly by the decay of naturally occurring radioactive isotopes of thorium, potassium, and uranium in the earth's core.

The definition has been cited according to Cutler. J. Clevelend and Christoper Morris editors), Dictionary of Energy. Elsevier, 2006, 502 pages

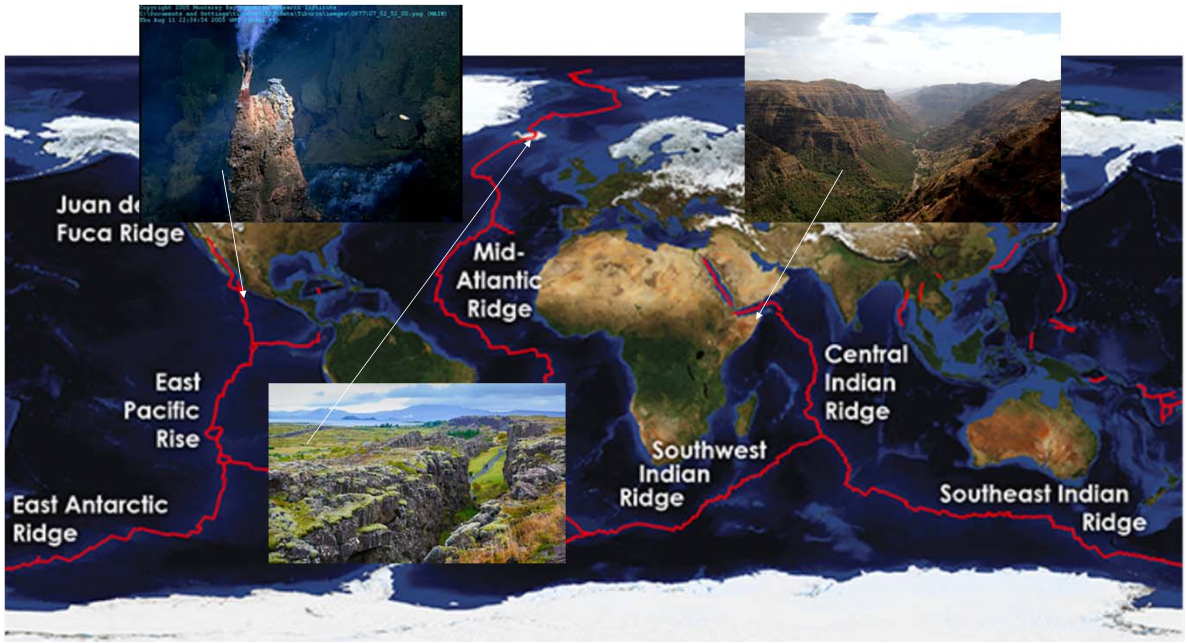


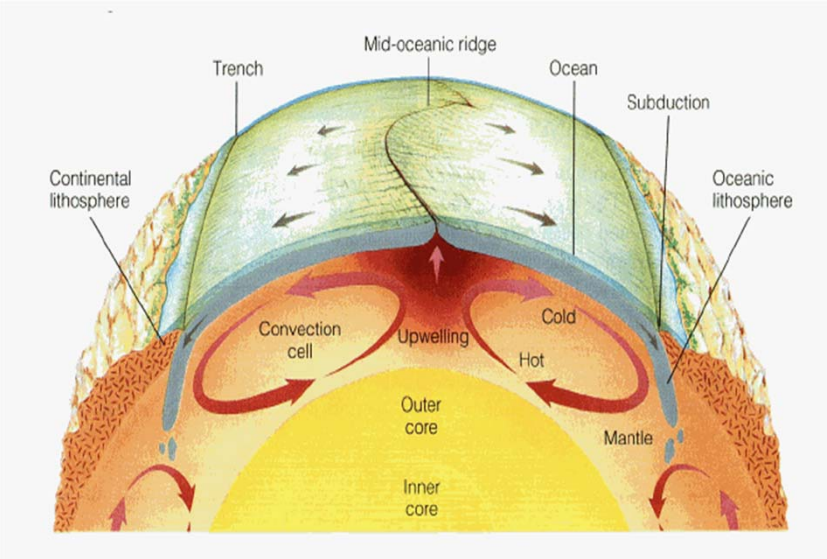
Geothermal Gradient

Geothermal gradient is the rate of increasing temperature with respect to increasing depth in the Earth's interior. Away from tectonic plate boundaries, it is about 25°C/km of depth in most of the world.

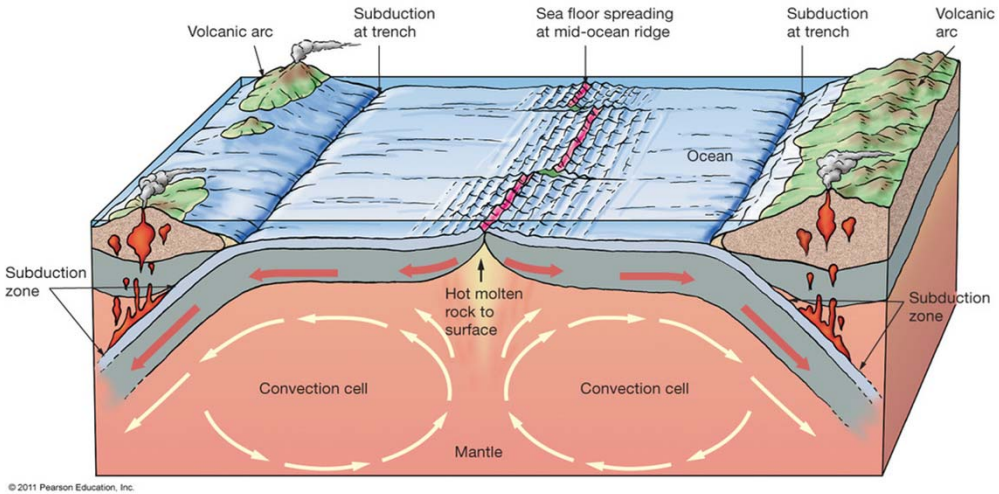


The Plate Tectonic of the Earth





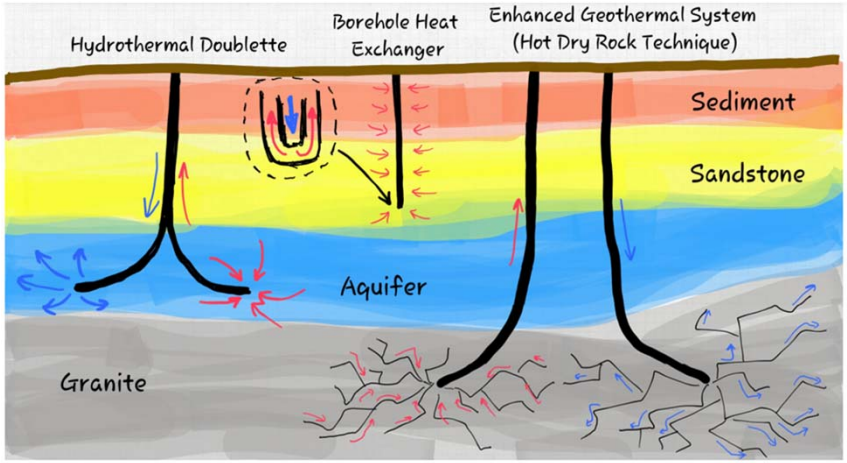
(Source: http://www.tendencias21.net/El-manto-terrestre-podria-contener-tanta-agua-como-el-oceano-Pacifico_a39232.html)



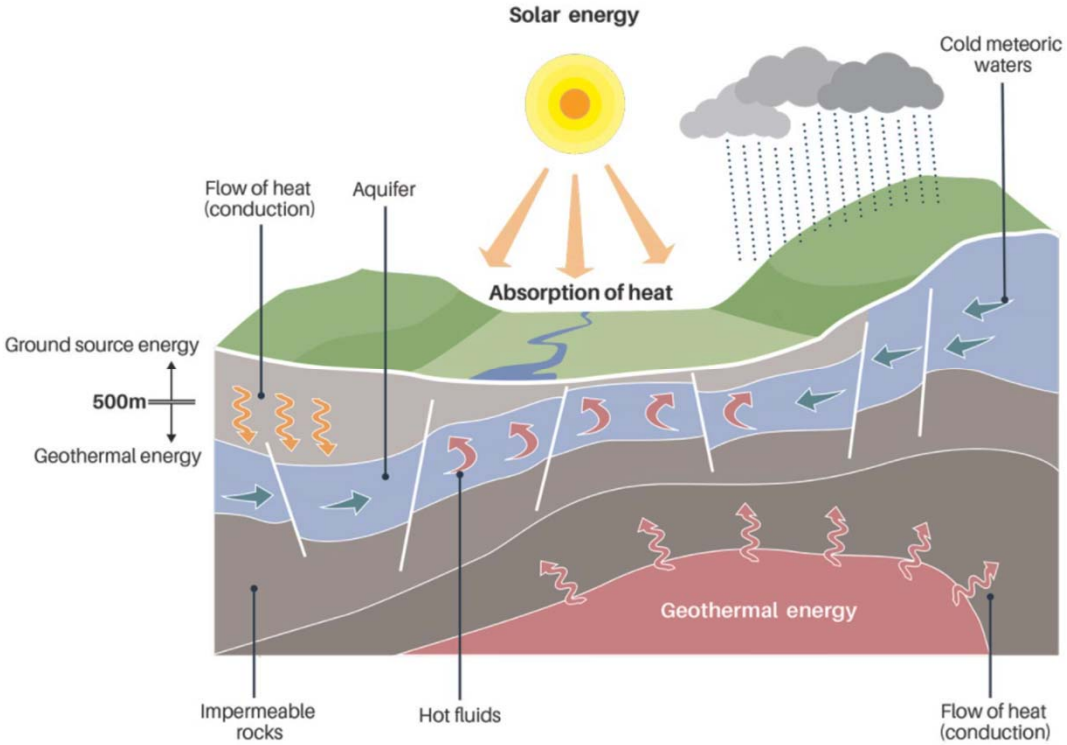
Geothermal systems

Geothermal system (*Dictionary of Energy*)

1. a localized geological environment in which circulating steam or hot water carries some of the earth's natural internal heat flow close enough to the surface to be employed for productive human use.
2. any technological system that makes use of this heat as an energy source; e.g., to power an electrical power plant or to heat or cool a building.



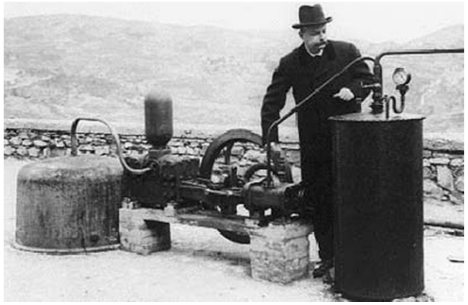
https://www.comsol.com/blogs/modeling-geothermal-processes-comsol-software/



https://www.bgs.ac.uk/geology-projects/geothermal-energy/

Utilisation of geothermal resources

The use of geothermal energy



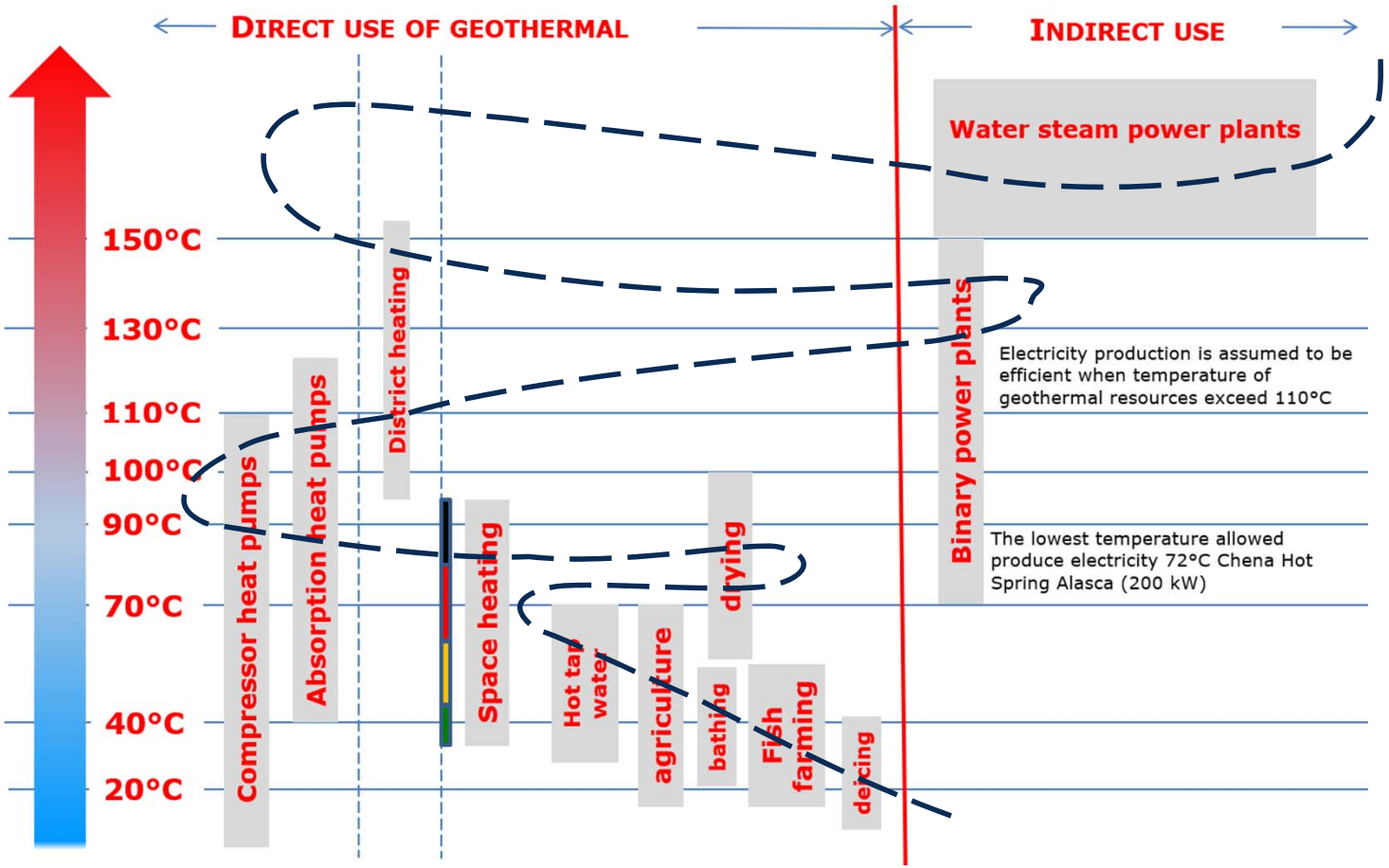
Direct

- space and district heating,
- greenhouse heating,
- agricultural drying,
- aquaculture pond and raceway heating,
- industrial applications,
- snow melting and cooling,
- balneology,
- geothermal (ground-source) heat pumps)

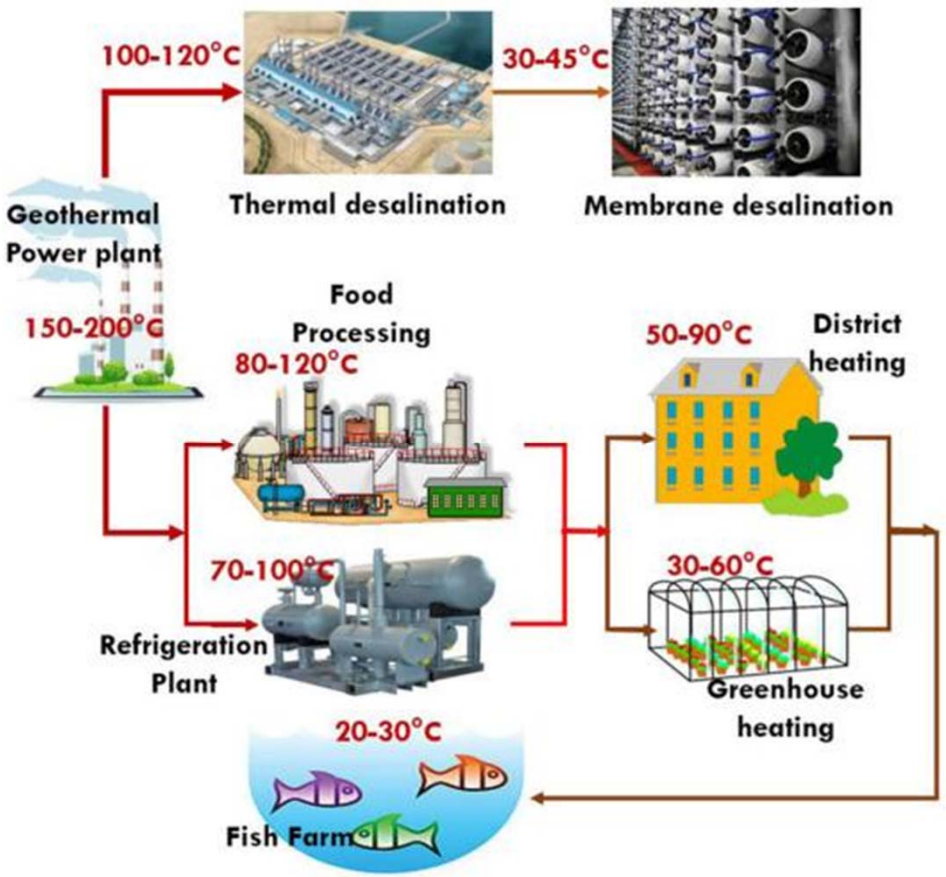
Indirect

electricity production

Effective direction of geothermal utilisation



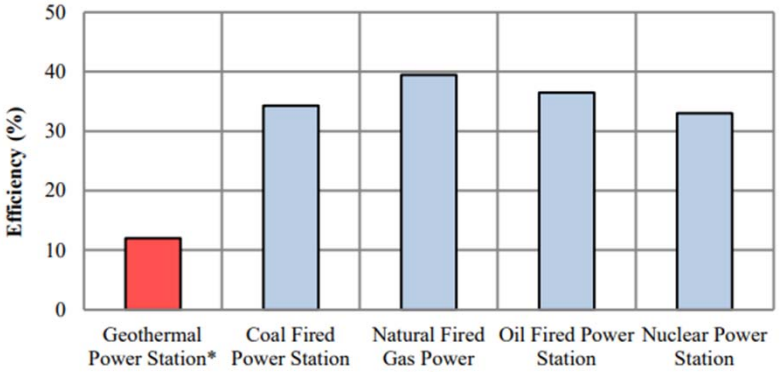
Effective direction of geothermal utilisation



Efficiency of **direct use of geothermal** is decreased by heat losses in a district heating: ~ 8 ÷ ~15%.

It is similar or higher than in a case of any conventional energy carrier.

Efficiency of **indirect use of geothermal**:



Thermal power efficiency *(source: Moon & Sadiq, 2012)*

In both cases above, geothermal is clean and renewable.

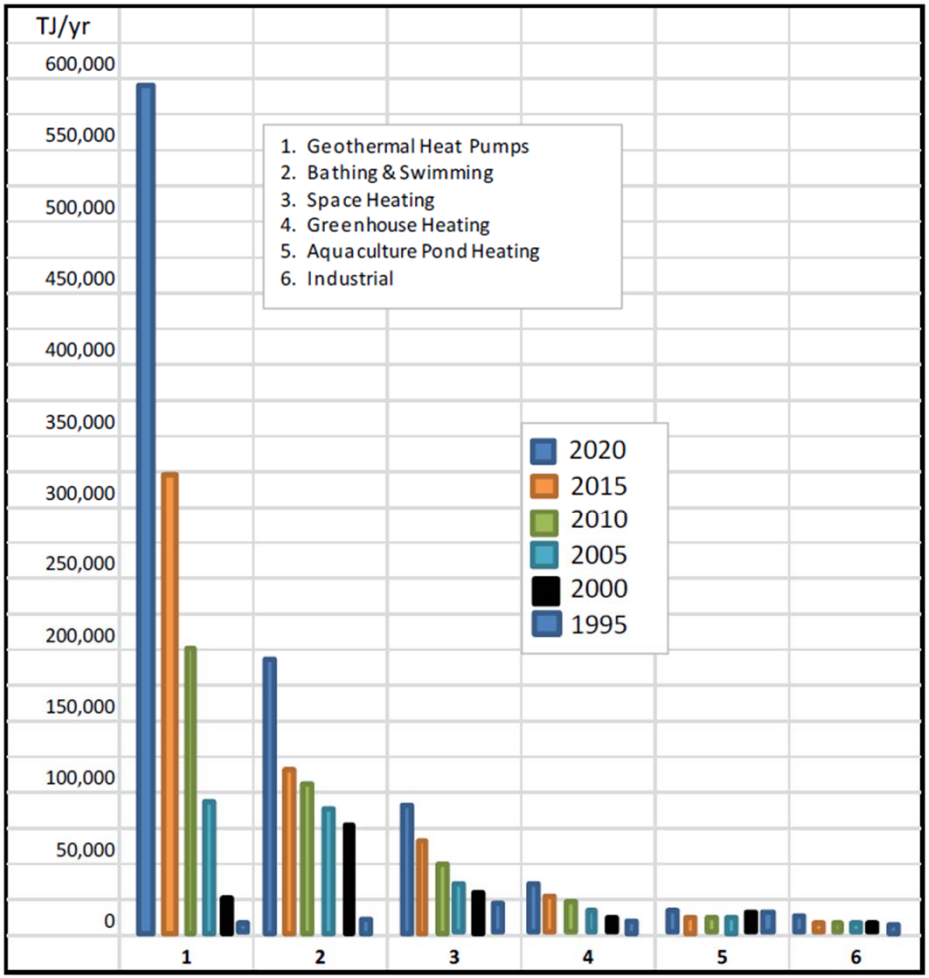
World leaders, direct use

Table 2: Worldwide leaders in the direct-use of geothermal energy including geothermal heat pumps.

MWt		TJ/year	
China	(40,610)	China	(443,492)
United States	(20,713)	Unites States	(152,810)
Sweden	(6,680)	Sweden	(62,400)
Germany	(4,806)	Turkey	(54,584)
Turkey	(3,488)	Japan	(30,723)

Table 3: Worldwide leaders in the direct-use of geothermal energy in terms of population(per1,000).

MW/population		TJ/population	
Iceland	(7.00)	Iceland	(99.10)
Sweden	(0.67)	Sweden	(6.22)
Finland	(0.42)	Finland	(4.23)
Switzerland	(0.26)	Norway	(2.34)
Norway	(0.21)	New Zealand	(2.12)



Comparison of worldwide direct-use of geothermal energy in TJ/yr from 1995, 2000, 2005, 2010, 2015 and 2020

John Lund, Aniko Toth, Aniko Toth, Direct utilization of geothermal energy 2020 world wide review. Geothermics Volume 90, February 2021, 101915

World leaders, indirect use

Figure 4: Geothermal Power Plants (source ThinkGeoEnergy)

Table 3 – Ten nations having the most installed geothermal power generation in 2020

Country	MWe Installed in 2020		Country	MWe Installed in 2020
1. U.S.A	3,700		6. Mexico	1,105
2. Indonesia	2,289		7. New Zealand	1,064
3. Philippines	1,918		8. Italy	916
4. Turkey	1,549		9. Japan	550
5. Kenya	1,193		10. Iceland	755

ThinkGeoEnergy's Top 10 Geothermal Countries 2020 – installed power generation capacity (MWe)

ThinkGeoEnergy Top 10 Geothermal Countries - year-end 2020 (source: ThinkGeoEnergy)

Gerald W. Huttrer. Geothermal Power Generation in the World 2015-2020 Update Report. Proceedings World Geothermal Congress 2020+1