

# Economical and Environmental Issues

## Technology | Geothermal Energy

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## 5. Economical and Environmental Issues

### 5.1 Economical Consideration

Geothermal heat may be competitive for district heating where a resource with sufficiently high temperatures is available and an adaptable district heating system is in place. Geothermal heat may also be competitive in applications where there is a high, continuous, heat demand and where there is no need for a large distribution system, e.g. in greenhouses. Although geothermal electricity and heat can be competitive under certain conditions, it will be necessary to reduce the levelised cost of energy (LCOE) of less conventional geothermal technology.

#### 5.1.1 Investment Costs

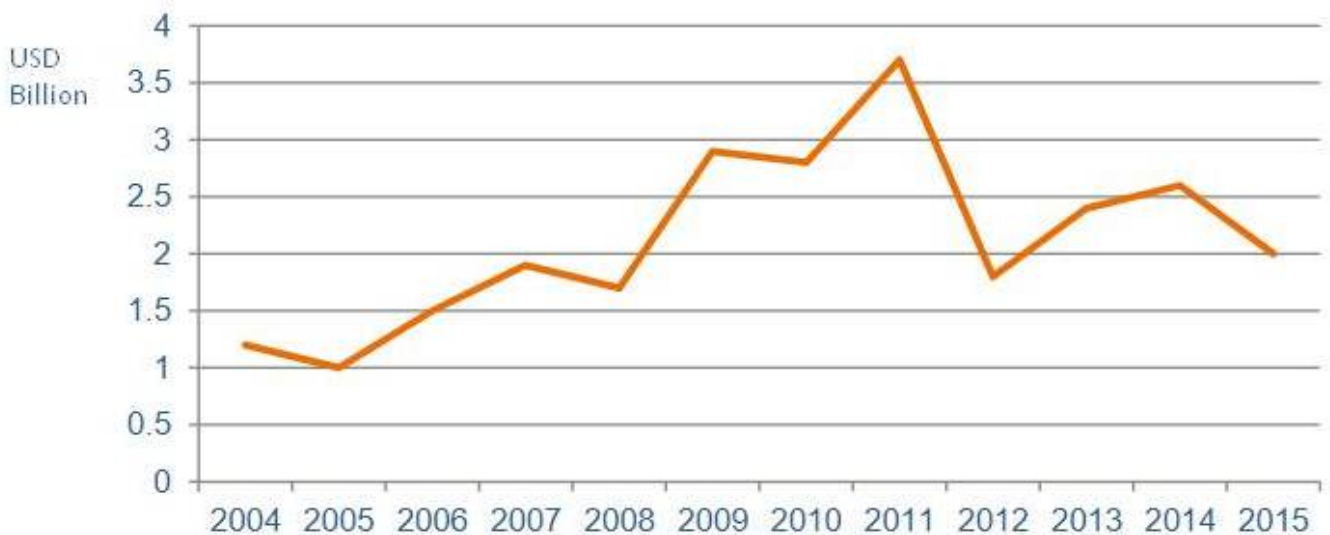
Geothermal electricity development costs vary considerably as they depend on a wide range of conditions, including resource temperature and pressure, reservoir depth and permeability, fluid chemistry, location, drilling market, size of development, number and type of plants (dry steam, flash, binary or hybrid), and whether the project is a green field

site or expansion of an existing plant.

Initial construction costs for geothermal power plants are high because geothermal wells and power plants must be constructed at the same time but the cost of producing electricity over time is lower because geothermal power plants are excellent sources of baseload power.

Operation and maintenance (O&M) costs in geothermal electricity plants are limited, as geothermal plants require no fuel. Typical O&M costs depend on location and size of the facility, type and number of plants, and use of remote control.

Global investment in 2015 was US\$2 billion, a 23% setback from 2014. During the period 2010-2014, around US\$20 billion were invested in geothermal energy by 49 countries for both direct use and electric power. Figure 1 illustrates the trajectory of yearly new investment in geothermal energy from 2004 to 2015.



**Fig. 1 – Yearly new investment in Geothermal energy, 2004-2015**

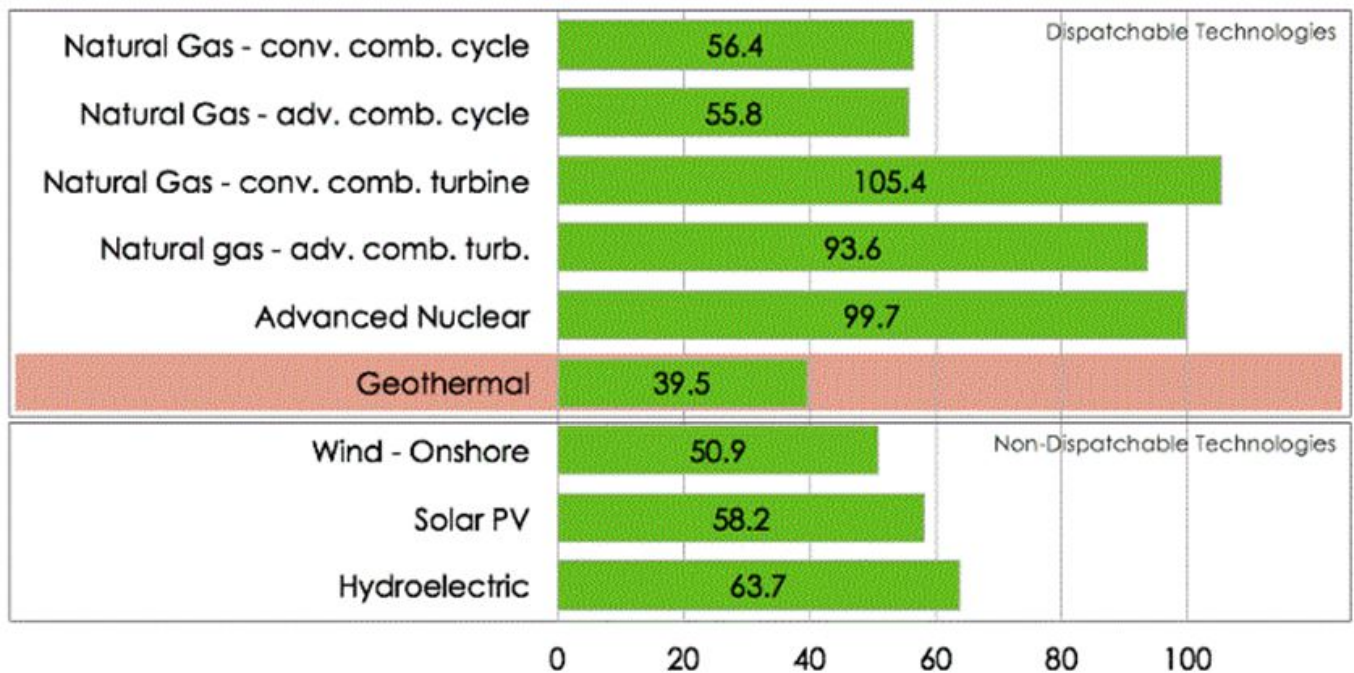
### **5.1.2 Comparative Cost Economics**

A number of international energy consultancies (Bloomberg, Lazard) and agencies (IEA, EIA) have assessed the levelised cost of geothermal generation plant compared with its rivals.

While in detail these costs differ depending on the present value of the currency used, capacity factors assumed, and the countries of origin, the relative ranking remains consistent.

In a paper published on 2016, EIA, the U.S. Energy Information Administration, shared its findings of a research on average values of levelized costs (LCOE) for generating technologies entering in service 2018, 2022 and 2040. The report highlights the competitiveness of geothermal energy in the U.S. energy market.

For the capacity weighted average LCOE based on 2015 \$/ MWh for plants entering into service in 2022, sees geothermal as very competitive.



**Fig.2 – Estimated levelized Cost of Electricity Generation (EIA, 2016)**

Geothermal energy remains a very attractive source of electricity, based on recent data published by the U.S. Energy Information Administration (EIA). Geothermal represents the lowest levelized cost of electricity in comparison to other sources of energy. The report provides also different scenarios, but all see geothermal as highly competitive on a LCOE basis. The above chart therefore provides only an overview for one scenario.

## 5.2 Environmental Impact

Power plants have greater environmental impacts than geothermal energy direct uses (ex. district heating system), which in turn have greater impacts than geothermal heat pumps. The impacts of geothermal power plants include changes to landscape; emissions into the atmosphere, surface and subsurface waters; noise; land subsidence, seismicity; and solid waste. The impact is generally proportional to the rate of fluid extraction.

Geothermal fluids contain dissolved gasses, commonly carbon dioxide and nitrogen with trace amounts of ammonia and hydrogen sulphide. In Table 1 it is presented the typical composition of geothermal gas. When two-phase geothermal fluid is separated into steam and water, or cooled in a heat exchanger, these gases emerge from the solution and are commonly vented to the atmosphere without adverse effects. However, hydrogen sulphide is a hazardous substance and many countries now regulate the management of H<sub>2</sub>S discharges. The USA and Italy have both mandated the installation of scrubbers to remove hydrogen sulphide from air discharges. Other countries place strict limits on H<sub>2</sub>S levels in air emissions.

	CO <sub>2</sub>	H <sub>2</sub> S	H <sub>2</sub>	CH <sub>4</sub>	NH <sub>3</sub>	N <sub>2</sub>	AR
Median	95.4	3.0	0.012	0.15	0.29	0.84	0.02
Maximum	99.8	21.2	2.2	1.7	1.8	3.0	0.04
Minimum	75.7	0.1	0.001	0.0045	0.005	0.17	0.004

**Tab. 1 Typical composition of geothermal gas**

The level of potential adverse environmental effects varies with the intensity of gas emissions. Low and moderate temperature fluids have significantly lower concentrations of dissolved gases than the high temperature, resources. Some of the district heating systems using low grade fluids from sedimentary basins are able to extract and inject geothermal fluids without any venting of gases.

However, "Geothermal power provides significant environmental advantages over fossil fuel power sources in terms of air emissions because geothermal energy production releases no nitrogen oxides (NO<sub>x</sub>), no sulfur dioxide (SO<sub>2</sub>), and much less carbon CO<sub>2</sub> than fossil-fueled power".

Air pollution can be virtually eliminated by the use of binary power plant design. That produce very low emission of CO<sub>2</sub>. For dry steam and flash plants emission of CO<sub>2</sub> are 0.02 pounds per kilowatt-hour (lb/kWh), compared to 1.32 lb/kWh from natural gas, 1.97 lb/kWh from oil, and 2.09 lb/kWh from coal.

Water use is an issue with conventional power plants. Even though geothermal plants use water and steam as fuel they use less water than coal, oil or nuclear plants. For geothermal generation, dry steam and flash plants use about 20 liters of freshwater per megawatt-hour of electricity (MWh) produced, while binary air-cooled plants use no fresh water.

This is an extremely low amount compared to coal plants which use 1,370 liters per MWh e, oil plants which use about 1160 liters per MWh or nuclear plants which use about 1700 liters per MWh (Lund 2006, 50).

In the case of direct-use application, the discharge of effluent is a potential source of pollution. Low and moderate temperature geothermal fluids, usually used in direct-use applications, typically contain low levels of chemicals and the discharge of effluent is rarely a major problem (Dickson and Fanelli 2004, 55).

Thermal pollution is a concern, particularly for aquatic environments, and a 2 to 3 °C increase in the temperature of a body of water as a result of discharging effluent could damage an ecosystem.

Although binary geothermal power plants emit very low emissions they create significant waste heat. Cogeneration in which the waste heat is utilized for producing power or heating, and the implementation of cascading uses is recommended to reduce the amount of waste heat. Cascading uses is the use of geothermal wastewater for multiple applications at decreasing temperatures. For example, wastewater from power generation is still hot enough to be

used for space heating, followed by agricultural use, balneology, and finally fish farming.

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## References:

- Geothermal Energy Association: [www.geo-energy.org](http://www.geo-energy.org)
- EIA – [www.eia.gov](http://www.eia.gov)
- IEA – International Energy Agency – Technology roadmap geothermal heat and power
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