GEOTHERMAL CO_2 REINJECTION

THE CONCEPT

Geothermal carbon dioxide (CO_2) reinjection returns naturally occurring geothermal CO_2 back underground to where it came from. "Reinjection" is a specific term used in the geothermal industry to describe injecting something back into the reservoir which came from there in the first place. There are several key differences between geothermal CO_2 reinjection and fossil fuel carbon capture and storage (CCS).

CO2 REINJECTION ALSO KNOWN AS

NCG reinjection

Reinjected gases also include naturally occurring CH_4 (methane) and H_2S (hydrogen sulphide). Together these three gases are called Non-Condensable Gases (NCG). CO_2 and methane are greenhouse gases, but H_2S is not.

CO_2 sequestration

Sequestration describes trapping or isolating something, in this case CO_2, underground.

WHAT IS A GEOTHERMAL RESERVOIR?

In common use the term "reservoir" usually refers to a body of fresh water such as a dam/artificial lake. However, a geothermal reservoir is underground. Rocks are packed together at high pressure, and small spaces and fractures are filled with geothermal fluid (which is hot water and sometimes steam). The geothermal fluid is hot due to nearby volcanic activity. In geothermal the combination of steam and water is simply called "fluid".

The geothermal fluids are not motionless underground - the systems are dynamic. The fluids move, rising towards the surface in a plume as shown in the figure below.

WHERE DOES THE CO2 COME FROM?

The CO_2 and other gases in geothermal systems are naturally occurring, coming from the volcanic magma (molten rock). The amount of CO_2 present can also be affected by reactions between the geothermal fluid and the reservoir rocks.

Underground the CO_2 is dissolved in liquid (geothermal fluid). This liquid boils when it moves up production wells, and the CO_2 is released into the steam. The steam is utilised for power generation and CO_2 is released in the process.

NEW ZEALAND GEOTHERMAL IS LOW-CARBON

New Zealand geothermal power stations have significantly lower CO_2e emissions intensities on average compared to fossil fuel plants.

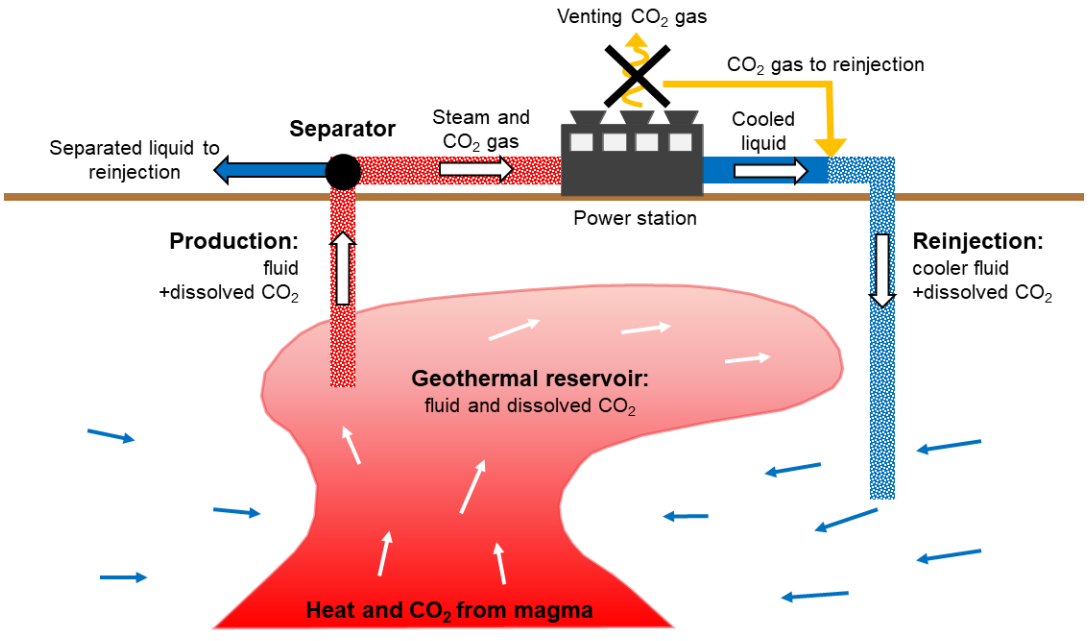
CO_2 AND CO_2e

CO_2e means CO_2-equivalent, which is CO_2 plus methane (CH_4) converted into an equivalent amount of CO_2. Both CO_2 and CH_4 are greenhouse gases.

CO_2e is the international standard for reporting greenhouse gas emissions.

In all parts of this document "CO_2" actually refers to "CO_2e".

Geothermal power stations have different levels of emissions as each geothermal reservoir naturally contains different levels of dissolved CO_2. For example, Rotorua, Ohaaki and Ngāwhā have high levels while others such as Wairakei are much lower. Various NZGA papers have emissions from all New Zealand's geothermal power stations and more (see references). The World Bank ESMAP Report is a comprehensive reference on the subject of geothermal CO_2 emissions globally.



REINJECTION OF CO_2

For many years it has been standard practice in the geothermal industry to reinject the cooled geothermal fluid back underground after it has travelled through the surface plant/power station. This is for environmental protection, and to maintain reservoir pressure closer to natural levels. Traditionally, CO_2 gas is vented to the atmosphere after the geothermal power station.

This venting of CO_2 has an impact on climate change. Therefore, the geothermal industry has been exploring ways to return the CO_2 underground instead.

Reinjection of CO_2 will be similar to the existing process for geothermal fluid reinjection, in the sense that it will minimise change to the reservoir, in this case CO_2 levels rather than reservoir pressure. The amount of dissolved CO_2 underground will be maintained closer to natural levels.

As geothermal fluid reinjection is already standard practice there is minimal additional infrastructure required to add the CO_2. Currently, pipelines direct the CO_2 gas stream up to the cooling towers of geothermal plants, for dispersal into the atmosphere. This gas stream would instead be connected to the fluid reinjection line where the CO_2 would be dissolved and carried underground. The CO_2 would spend just a few minutes above ground, contained within pipelines and plant, before being returned underground.

WHAT IS HAPPENING IN NEW ZEALAND NOW?

Some amount of CO_2 reinjection is already happening passively, and there are pilot trials to increase this amount.

PASSIVE AND ACTIVE

Passive CO_2 reinjection

Any CO_2 that is reinjected during normal power station operation. For some power station types this is up to 20% (binary stations).

Active CO_2 reinjection

When equipment is installed specifically to increase the amount of CO_2 being reinjected over and above the amount being reinjected passively.

For active CO_2 reinjection there are technical challenges to overcome such as corrosion of metal pipelines and scaling (buildup of minerals in pipes and wells). The geothermal operators in NZ are approaching this as a collective group, as the challenges will be surmounted faster together.

In the past, active CO_2 reinjection has not been attempted in New Zealand due to technical challenges, and a lack of financial incentive or regulatory requirement. This has changed recently as even low-carbon sources of energy, such as geothermal, are being reviewed as momentum builds towards a net-zero carbon future.

WHAT HAPPENS TO THE CO_2

When CO_2 goes back underground via the reinjection well, it does not rise towards the surface as it is no longer in gaseous form. Instead, the CO_2 is dissolved in liquid and circulates back into the geothermal reservoir where it re-joins the CO_2 already dissolved in the fluid.

There is some potential for the CO_2 to form minerals and be immobilised underground, for example at the EU-funded Carbfix project in Iceland. NZ has different types of reservoir rocks and the potential for mineralisation is less, but some mineralisation may still occur.

DIFFERENCES FROM CCS

Carbon Capture and Storage (CCS) involves capturing CO_2 created by burning fossil fuels, and storing it underground elsewhere. The main differences to geothermal CO_2 reinjection are:

- No combustion: geothermal CO_2 is naturally occurring.
- No "capture": streams of CO_2 already exist, they just need to be redirected.
- No transport of CO_2 involved (and no liquefaction required): the gases come up and go back down into the same reservoir.
- No buoyancy: the CO_2 is not in gaseous form underground and does not rise towards the surface, it is dissolved in liquid.

REFERENCES

GNS Science animation:

https://www.youtube.com/watch?v=B-5s2LxnejQ

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https://nzgeothermal.org.nz/

World Bank ESMAP Report:

Fridriksson, T., Mateos, A., Audinet, P. and Orucu, Y. (2016): Greenhouse Gases from Geothermal Power Production. ESMAP Technical Report 009/16.

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