Silica in Geothermal

EGEE 497

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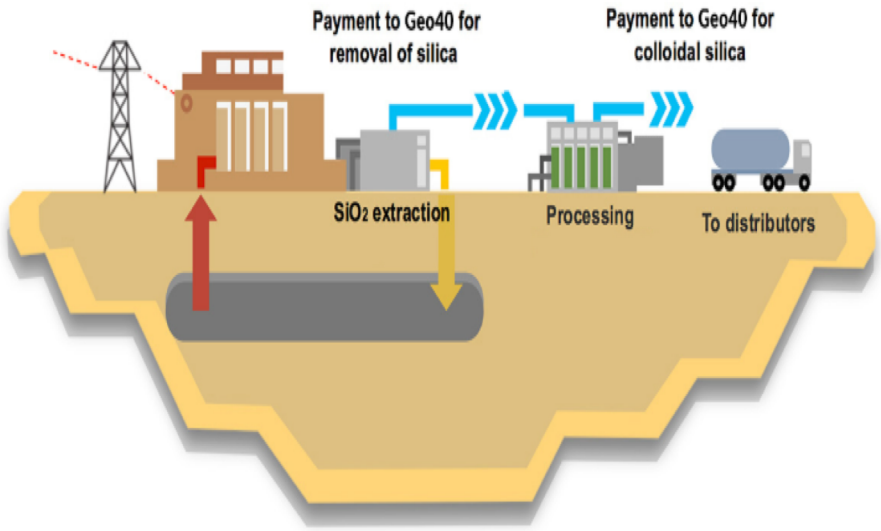
Mercury Energy (NZ)

- Five geothermal power stations:
  - Kawerau
  - Mokai
  - Rotokawa
  - Ngatamariki
  - Nga Awa Purua
- Run at full capacity around 95% of the time
- Recently drilled four new make-up wells to replenish fuel supply
- Note: roughly 15% of New Zealand's total power generation is geothermal ~900MW (with an additional 1000 MW possible)

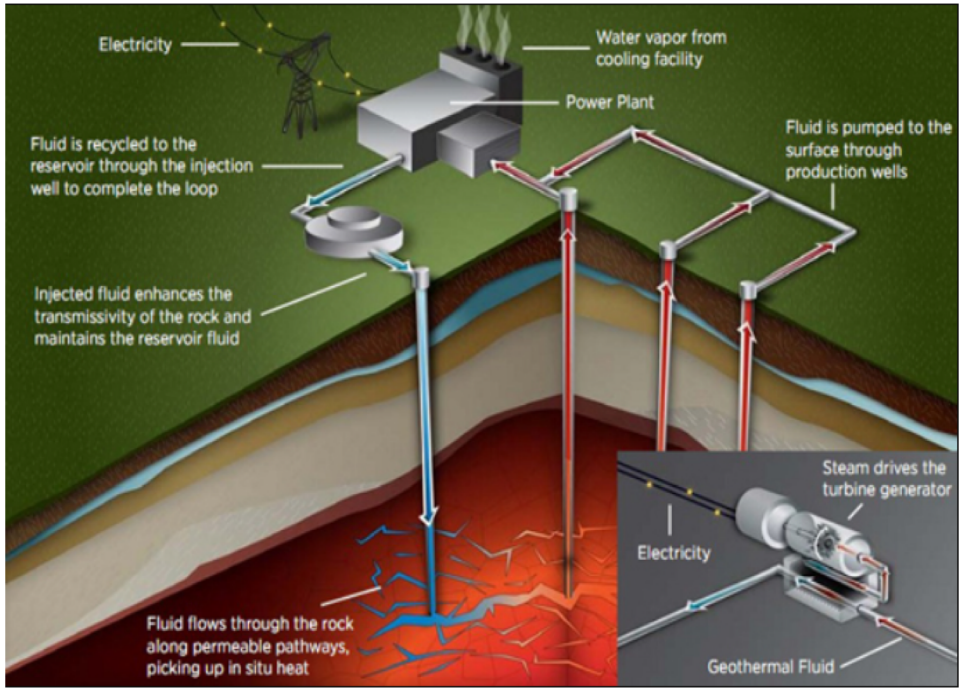
Geo40

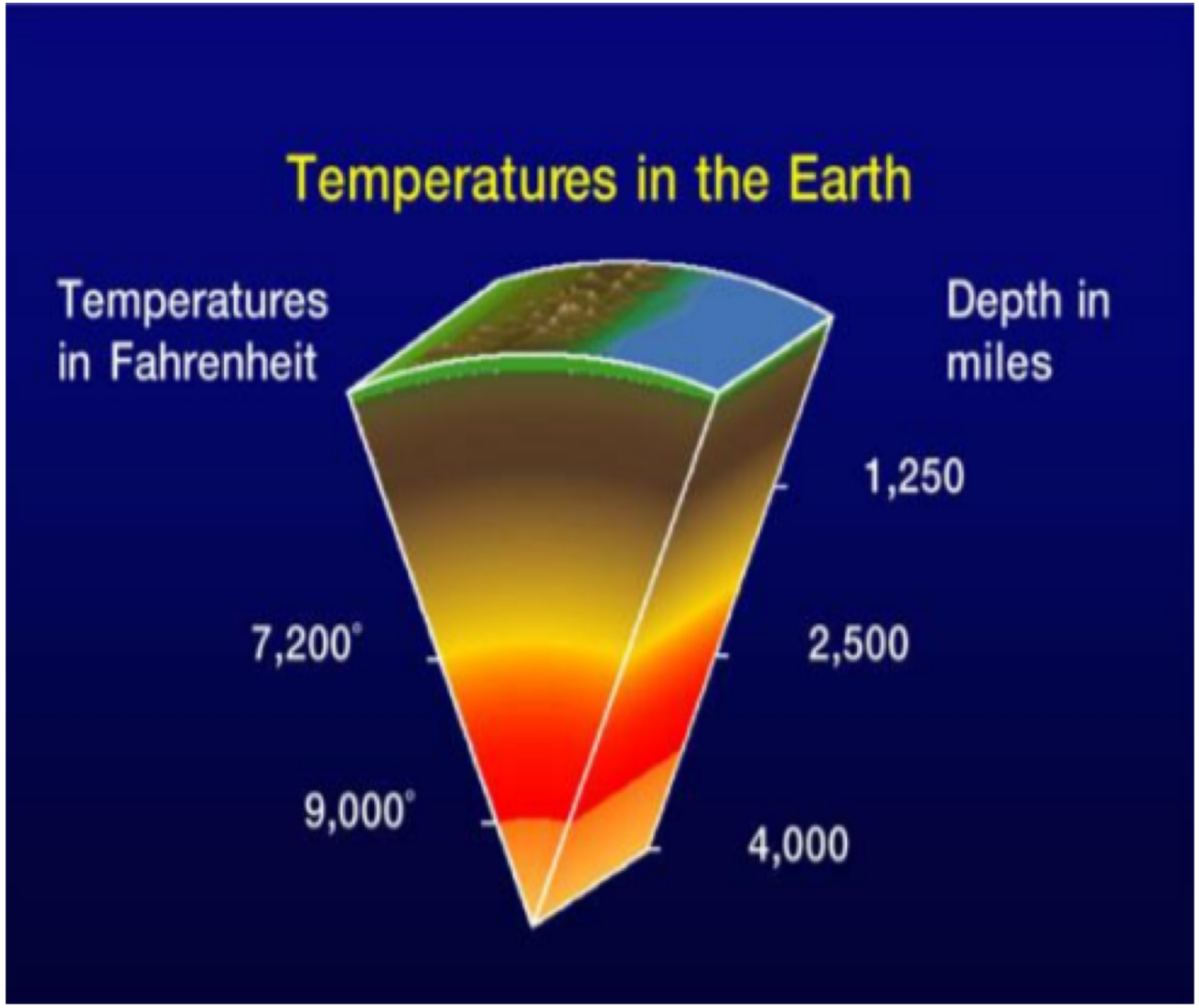
- Established in 2010
- Startup in New Zealand working on silica extraction



Geothermal process

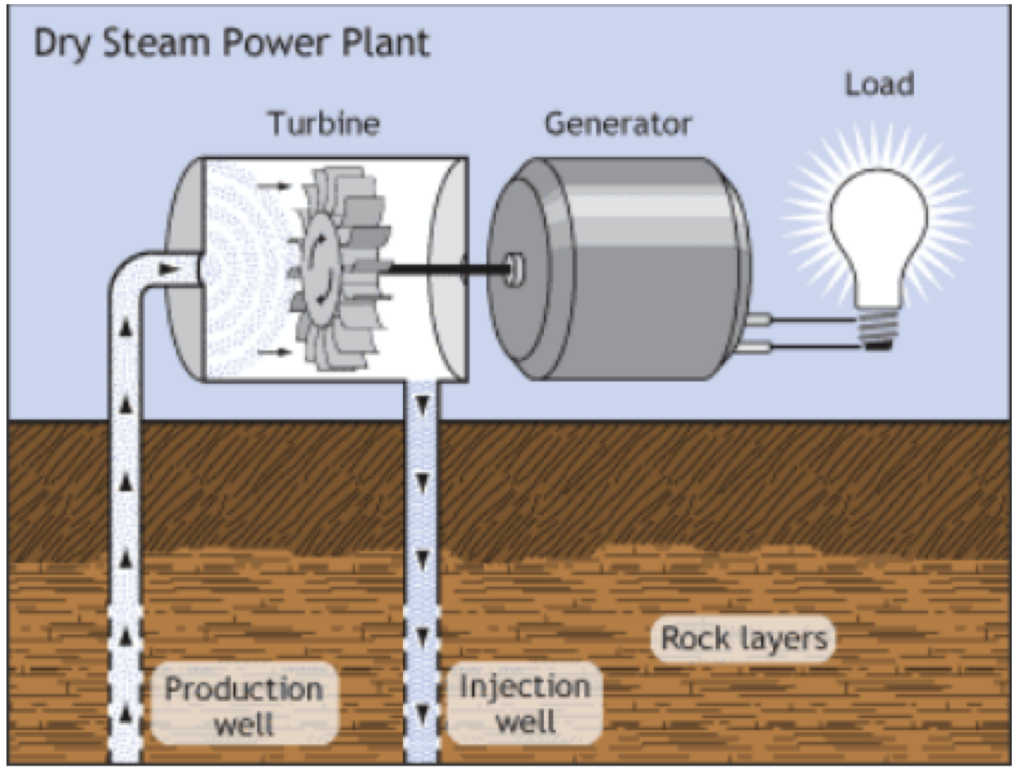
- Fluids are extracted between 200-300 degrees Celsius
- Fluid must be pumped into the well or exist naturally
  - Usually incorporate both for better efficiency
- Fluid is heated through natural fractures in the rock, or the fractures must be created
- There are three types of plants: Dry Steam, Flash Steam, Binary Cycle




Temperatures in the Earth
Temperatures in Fahrenheit
Depth in miles
1,250
7,200°
2,500
9,000°
4,000

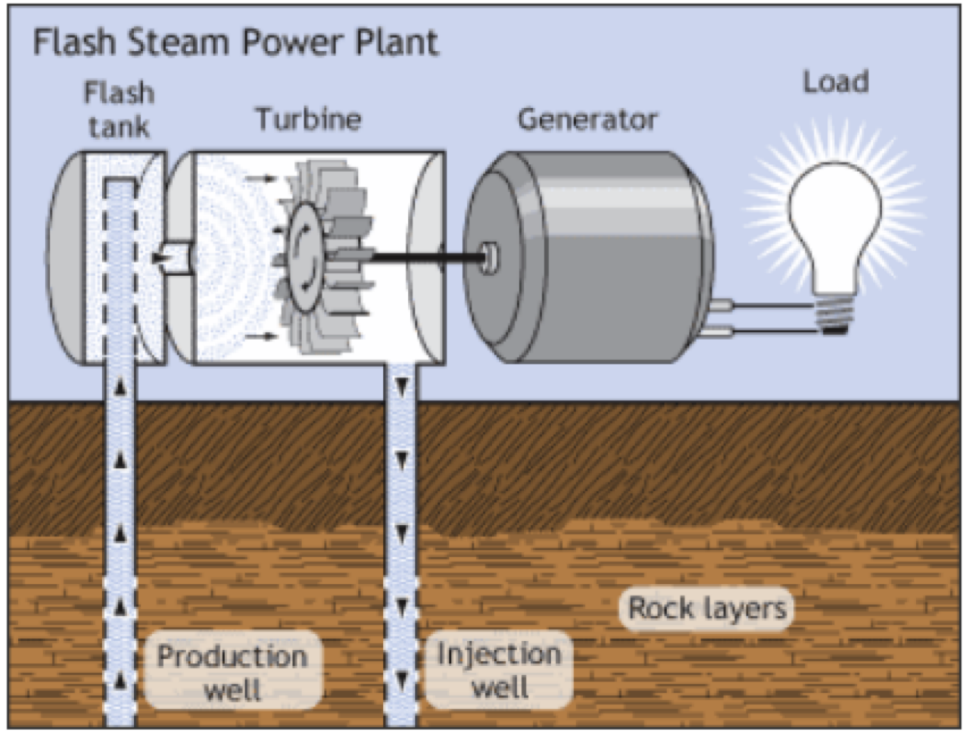
Dry Steam

- Emits only excess steam and minor amounts of other gases



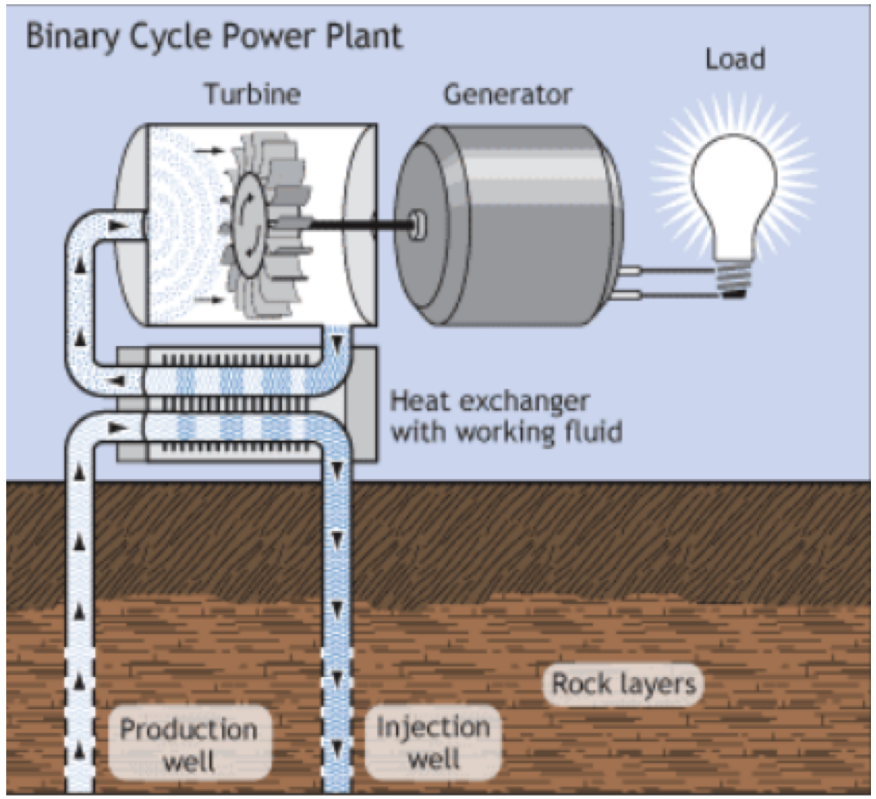
Flash steam

- Most common process
- Temperatures greater than 182^{o}C
- Pumped at high pressure to a tank of the surface at a much lower temperature
- Changes in pressure cause the fluid to “flash” or vaporize
- Vaporized fluid is then sent through the turbine
- Any excess fluid in the tank is sent to another tank to undergo the process again



Binary cycle

- Fluid is around 150°C
- Fluid from the geothermal reservoir never comes into contact with the turbine
- Fluid from the reservoir is used to heat a secondary fluid which has a much lower boiling point
- Closed loop system where nothing besides water vapor escapes the system
- Main use is for heating and other manufacturing applications



Problem

- Silica precipitating from the solution causes fouling/scaling in the system
- Also causes corrosion of the well
- Currently have to add sulfuric acid to keep the silica suspended in the fluid
- $H_4SiO_4 \rightarrow 2H_2O + SiO_2$

Figure 7: Corrosion of tubes (Kagel A., 2008).

Silica Precipitation

- Silica precipitation requires a pH of 8.2
- Using an electromagnetic field, the pH can be reduced to 7.3-7.8 and the settling rate is increased
- Settling rates were found to be from 7.1-9.7 cm/min at 100^{o}C and 3.4-4.6 cm/min at 40^{o}C
  - Compared to 1.3 cm/min where the silica was only alkalized
- This is why in New Zealand they add sulfuric acid back into the fluid

Heat exchangers

- Works through reverse osmosis
- Creates water and a concentrated brine
- Brine is then pumped into a reactor where chemicals are added to extract the silica
- The brine can then be pumped through other processes to extract other metals before the fluid is sent back for reinjection

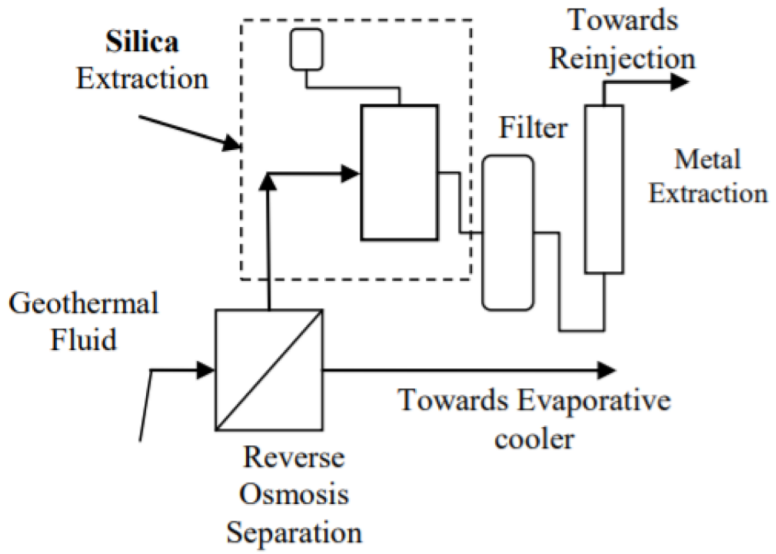


Figure 5: Extraction of silica from geothermal fluid (Parker, 2005)

U.S. Potential

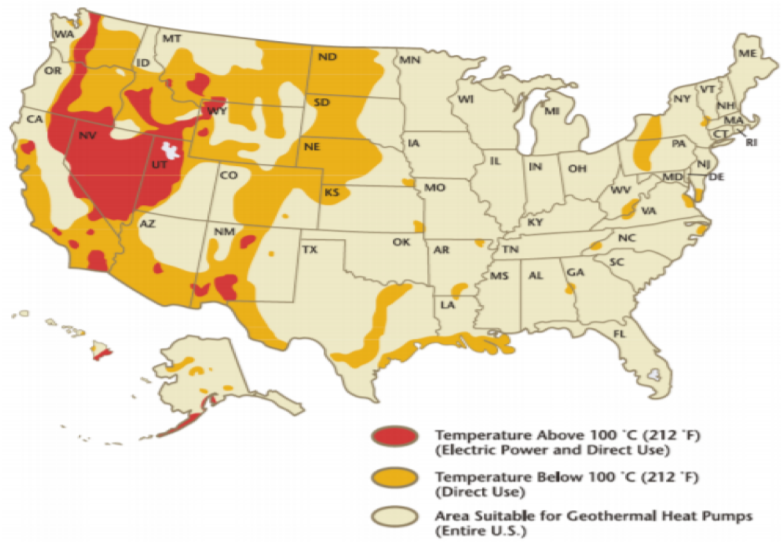


Figure 3: Temperature distribution throughout the USA for use of geothermal (Green and Nix, 2006)

	Salton sea, CA	Coso, CA	Dixie Valley, NV	Mammoth Lake, CA
Temp., (°C)	296	274	246	165
Silica, (mg/kg)	>461	>711	>599	~ 250
Boron, (mg/kg)	257	119	9.9	NA
Lithium, (mg/kg)	194-230	45	2-4	NA
Zinc, (mg/kg)	438	0.03	NA	NA

Conclusion

- Silica extraction provides another avenue for profit
- Example: two 50 MW power plants in CA
  - Silica extraction could provde $10.2-12.9 million per year
- Extraction can reduce costs through no longer needing to add excess sulfuric acid
- Causes a reduction in fouling/scaling and increase well life
- Can extract more than just silica
  - Once the silica is extracted other metals like gold, silver, lithium, manganese, zinc can be extracted

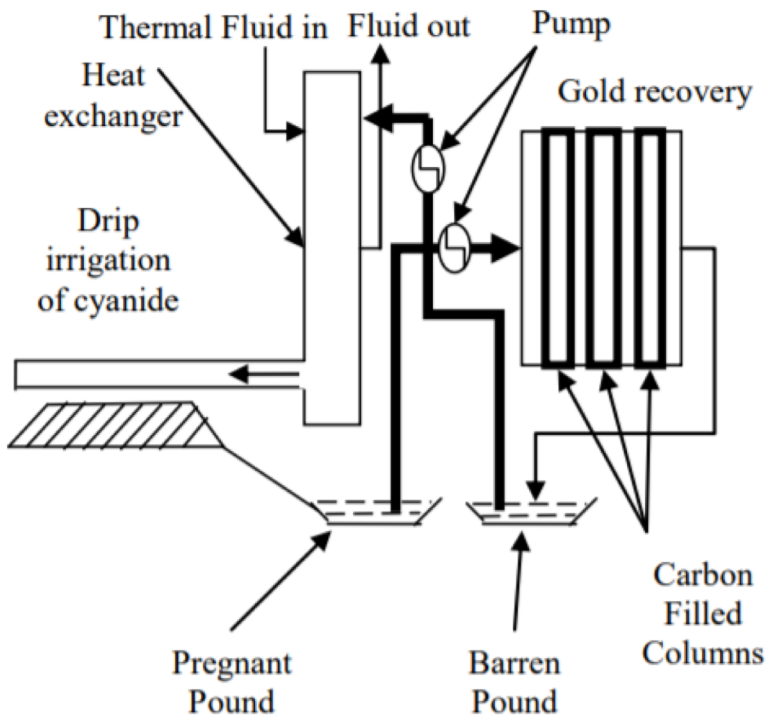
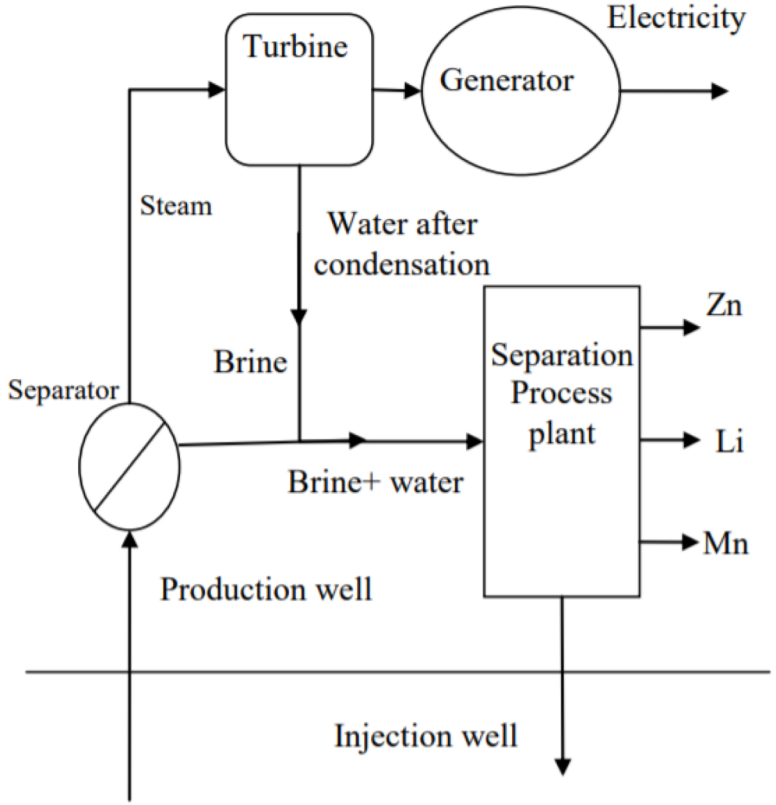


Figure 4: Idealized thermally enhanced heap leach (Trexler., et al 1990)



Sources

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