CO2-Plume Geothermal: Enabling CCS

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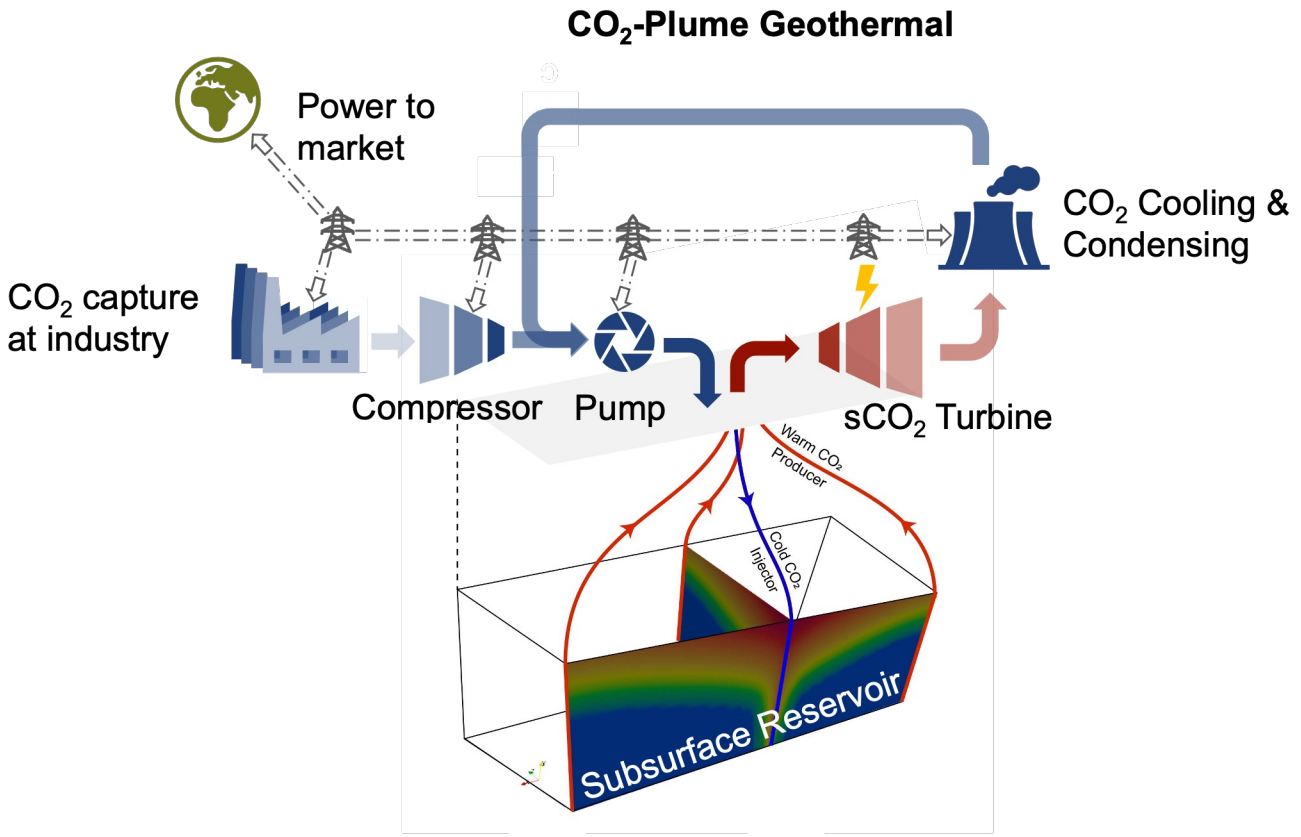
Introduction: CPG

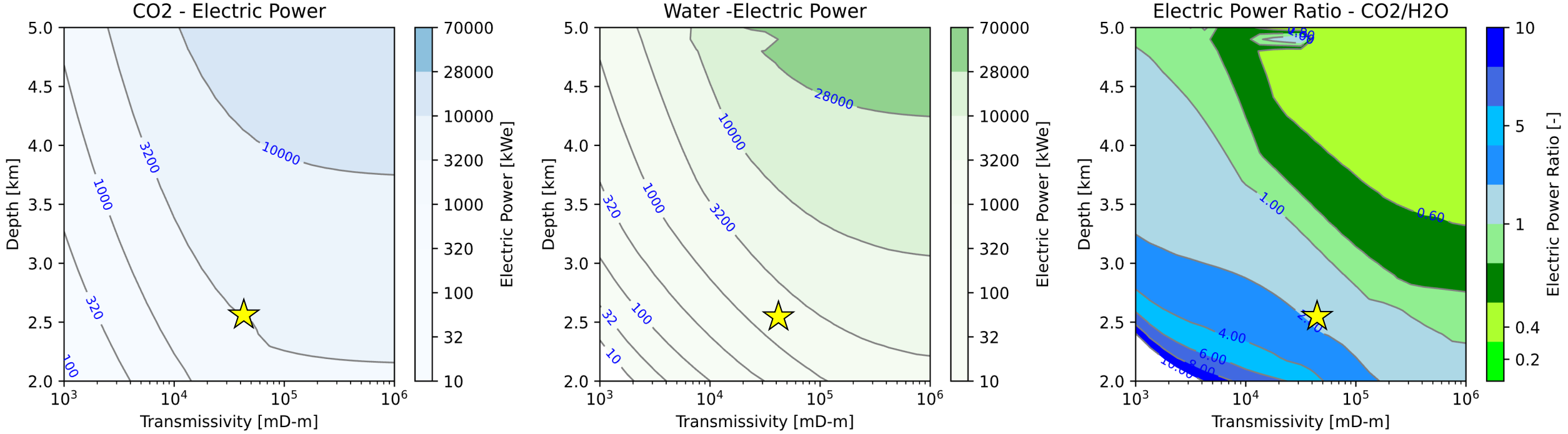
- Co-invented by Martin Saar, CO_2-Plume Geothermal (CPG) uses the benefit of CO_2 as a geothermal working fluid to turn CCS into true CCUS (both CO_2 utilization and 100% storage)

- Not just about producing power: CPG can benefit the base CCS project in several ways



Power production using CPG

- Comparison of using CO_2 compared to H_2O (5-spot, 1 km^2, 35°C/km, 41cm well diameter)
- Example plotted (★): 2x power produced with CO_2



Comparing CO_2 and H_2O as a geothermal working fluid

$$Thermal\ energy\ flux\ = \frac{kA}{L}\left(\frac{\rho}{\mu}\right)\Delta P\ C_p \Delta T$$

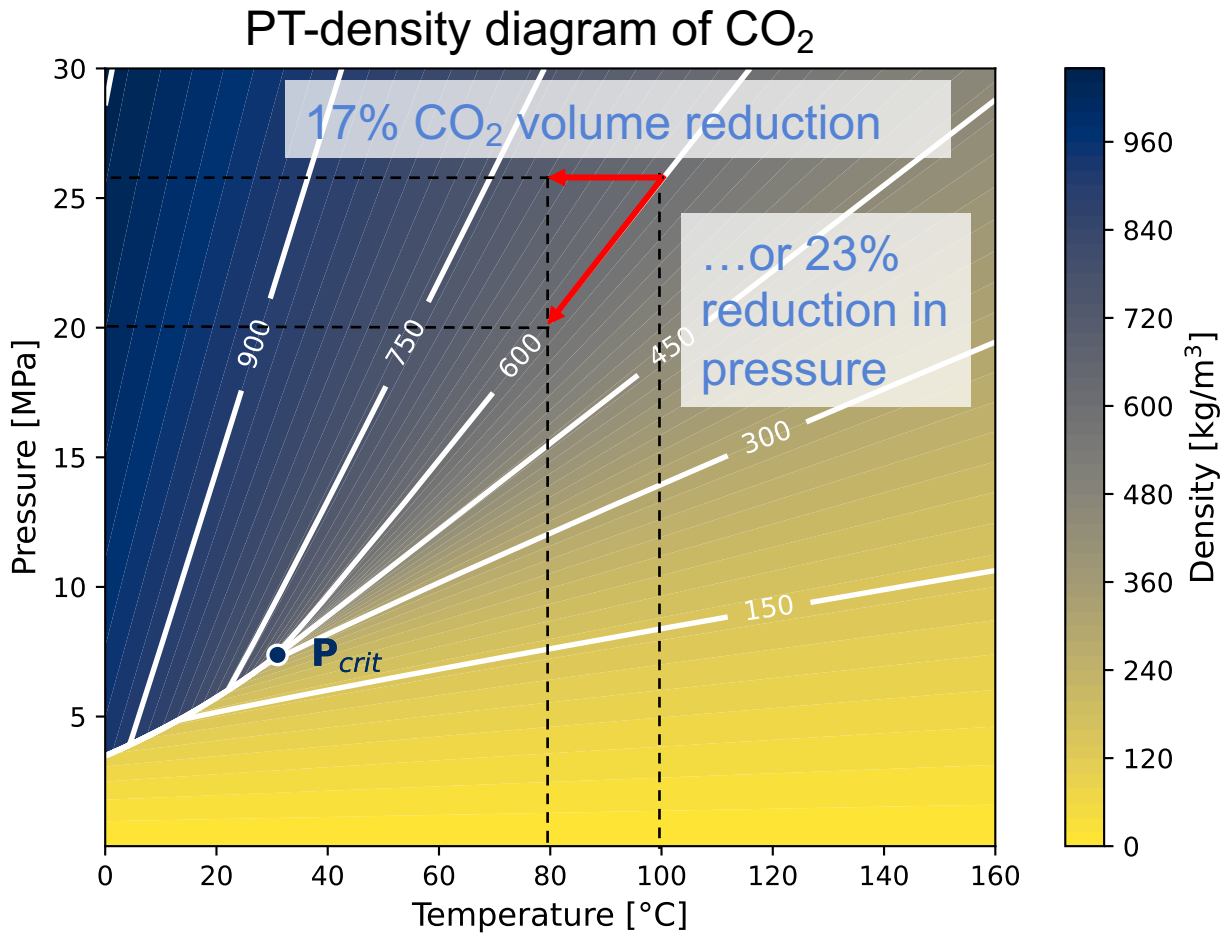
→ ~2x using CO_2

~4x ~0.5x

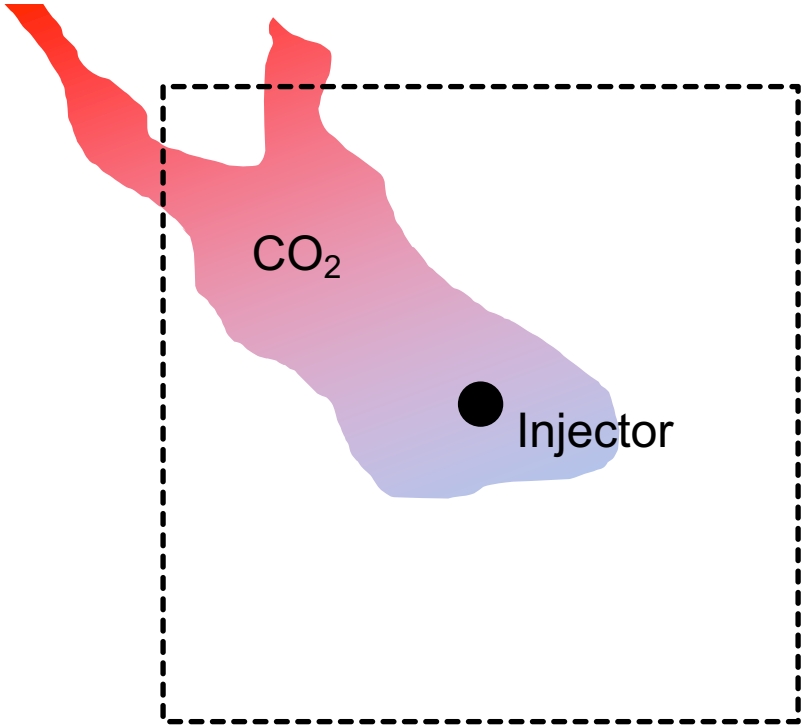
- Impact of CO_2 dynamic viscosity > reduction in heat capacity, compared to H_2O
- Additionally, thermosiphon effect: density difference between hot and cold CO_2 in producer and injector wells

Pressure reduction and CO_2 storage capacity (1/2)

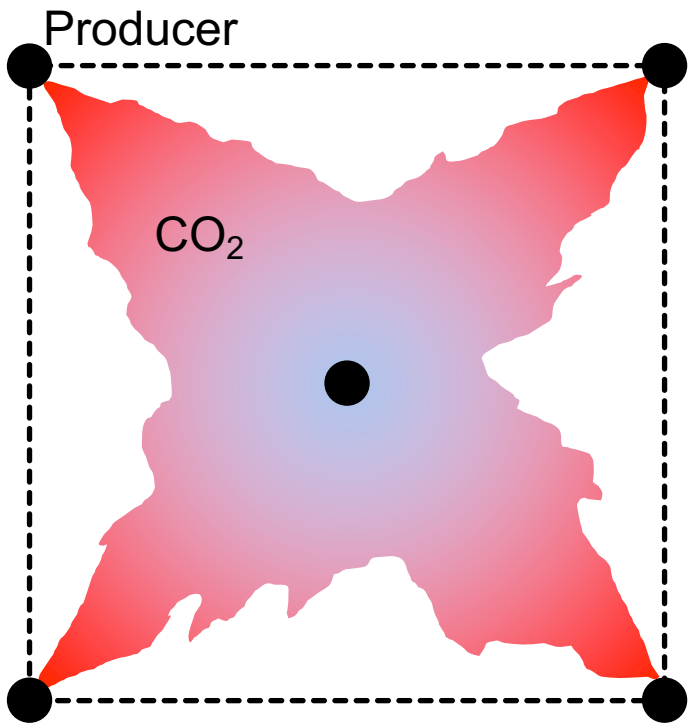
- Extracting reservoir energy (heat) decreases the CO_2 volume (i.e. increased storage capacity), or reduces the reservoir pressure
- Plotted example: -20 degC → 17% reduction in CO_2 volume (isobaric) or 23% reduction in pressure (constant volume assumption)



Pressure reduction and CO_2 storage capacity (2/2)



CCS:
- Limited CO_2 plume control
- Sweep penalty



CPG:
- Control of local pressure gradients
- Volumetric sweep upside

Capex

Flexibility to convert producers to injectors

- Opportunity for reduced injection well redundancy compared to CCS
- Production wells at end-of-CPG-life could be repurposed as CCS injectors: sustain CCS injection capacity level

Dual use of wells

- Production wells provide valuable information: potential for MMV (Measurement, Monitoring and Verification) cost savings

Injector uptime

- Salt precipitation during flowback is an injectivity concern at Aquistore (Talman et al, 2020)
- CPG enables higher injection well uptime: can continue to inject CO_2 if capture plant is not operating

Salt Precipitation at an Active CO_2 Injection Site. Talman et al., 2020

Public acceptance

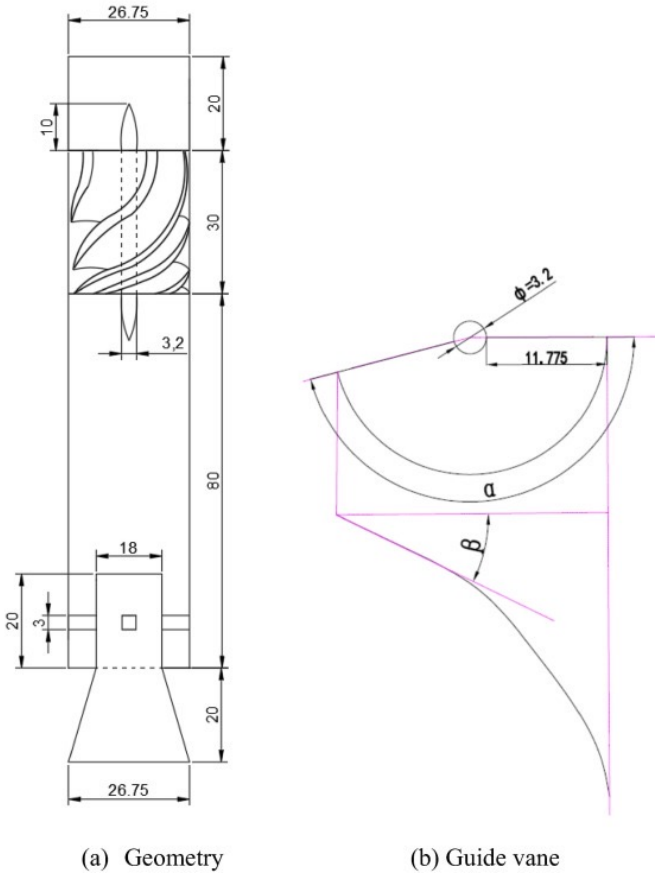
- CO_2 disposal with benefits: power to communities
- *Farajzadeh et al. (2019)* estimated that CCS projects emit 0.43–0.94 kg of CO_2 per kg of CO_2 stored

  → on-site power production lowers carbon intensity of CCS

Hrkac, 2021. protests against CCS

Challenges

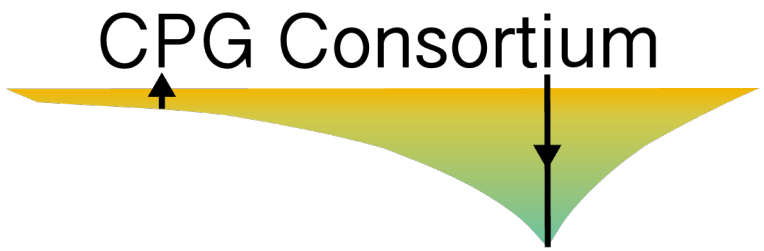
- Lower temperature CO_2 turbines, high-pressure CO_2 cooling & condensing require development
- Produced fluids need to be treated before re-injection
- Regulatory support for CPG



Li et al., 2021. Gas-liquid separation using a micro axial flow cyclone separator

CPG Consortium

- Launched in March 2023 with Shell, Petrobras, Holcim, Ad Terra Energy, ETH Zurich, and several academic partners
- Objective: demonstrate the potential and technical feasibility of commercial-scale CPG to enable investment decisions
- Working towards a field demonstration during Phase II of the consortium



https://geg.cpg.ethz.ch

Conclusion

- CPG is an emerging technology with potential to improve CCS projects
- Interested to learn if you see overlaps with your area of research / projects

Thank you for your attention!