

The Gasometer-based CO₂ Plume Geothermal (CPG) Energy Storage System

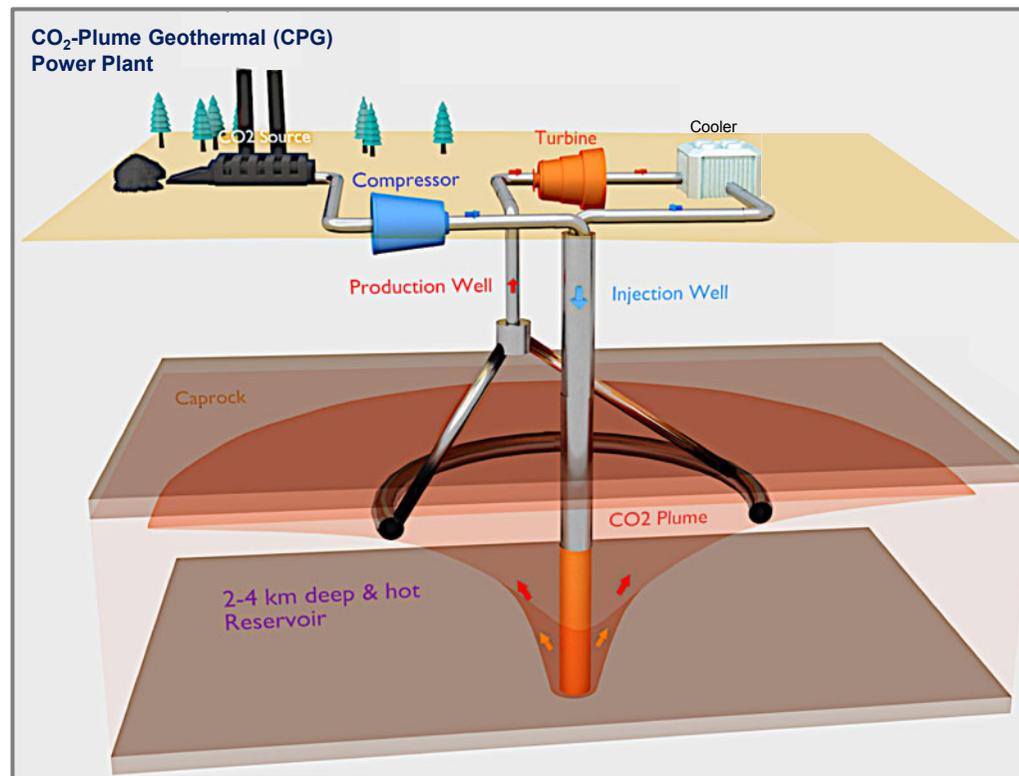
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ADD Energy Storage

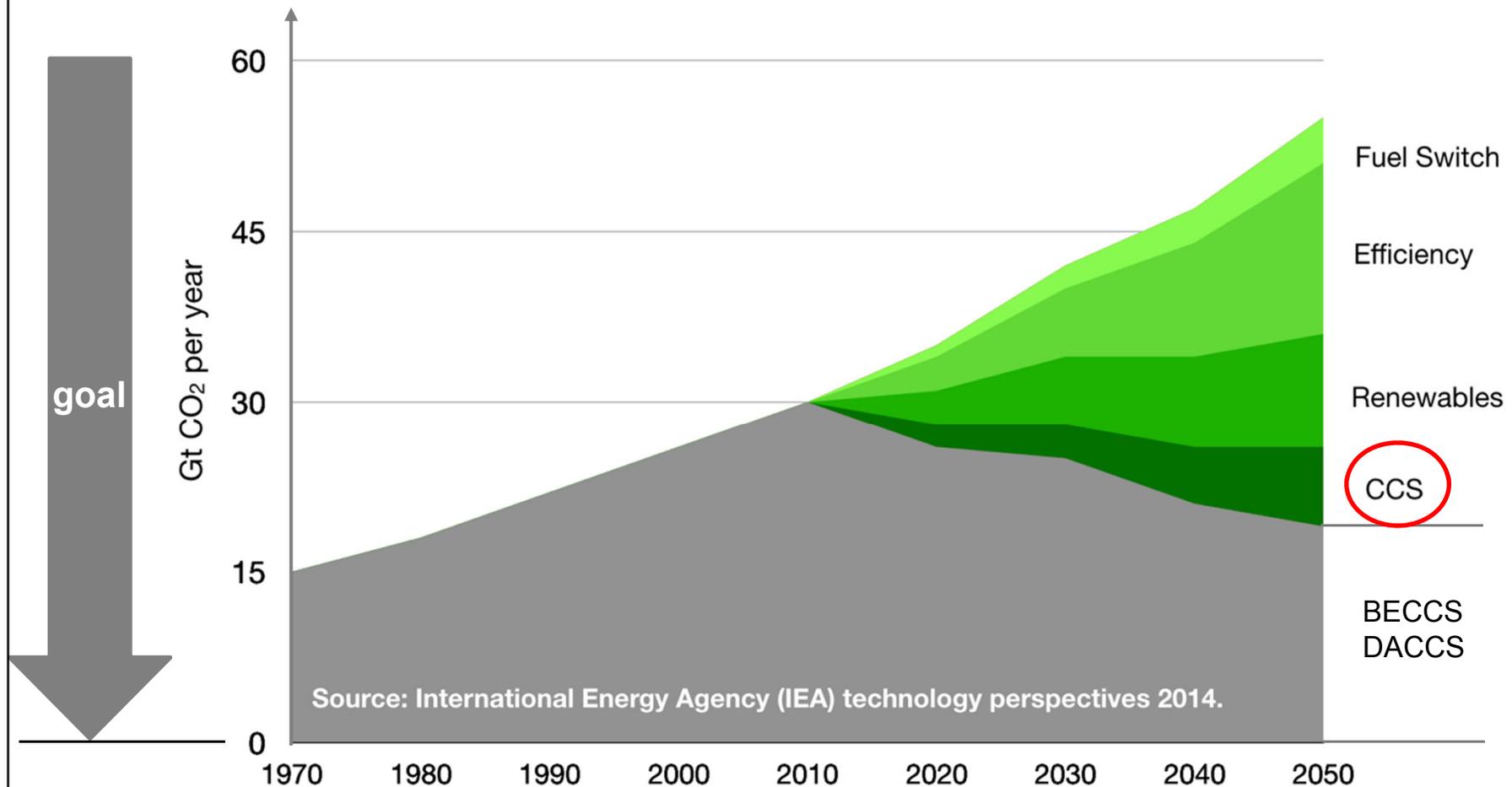
EBE1: Subsurface Storage
(Earth Battery 1)

EBE2: Surface Gasometer Storage
(Earth Battery 2)

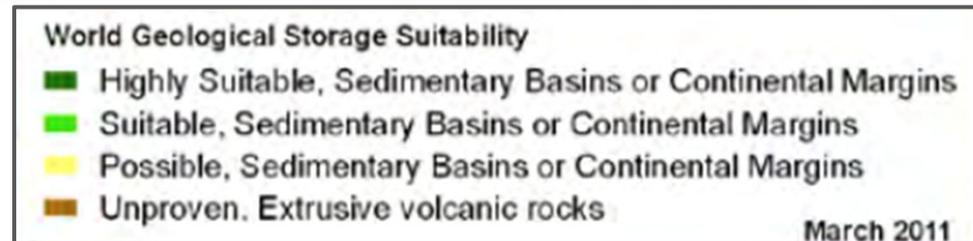
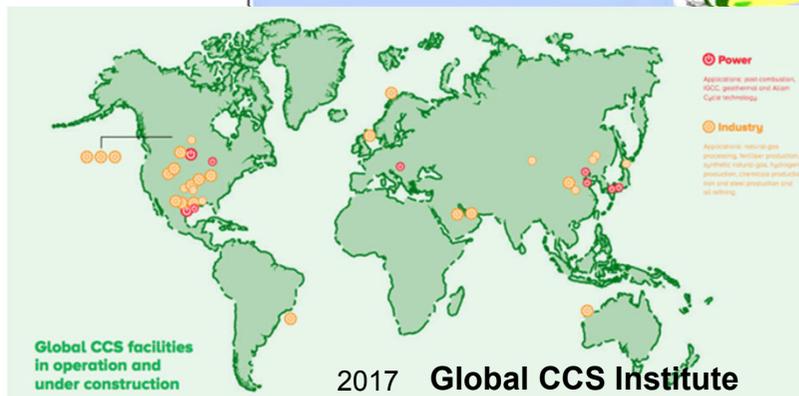
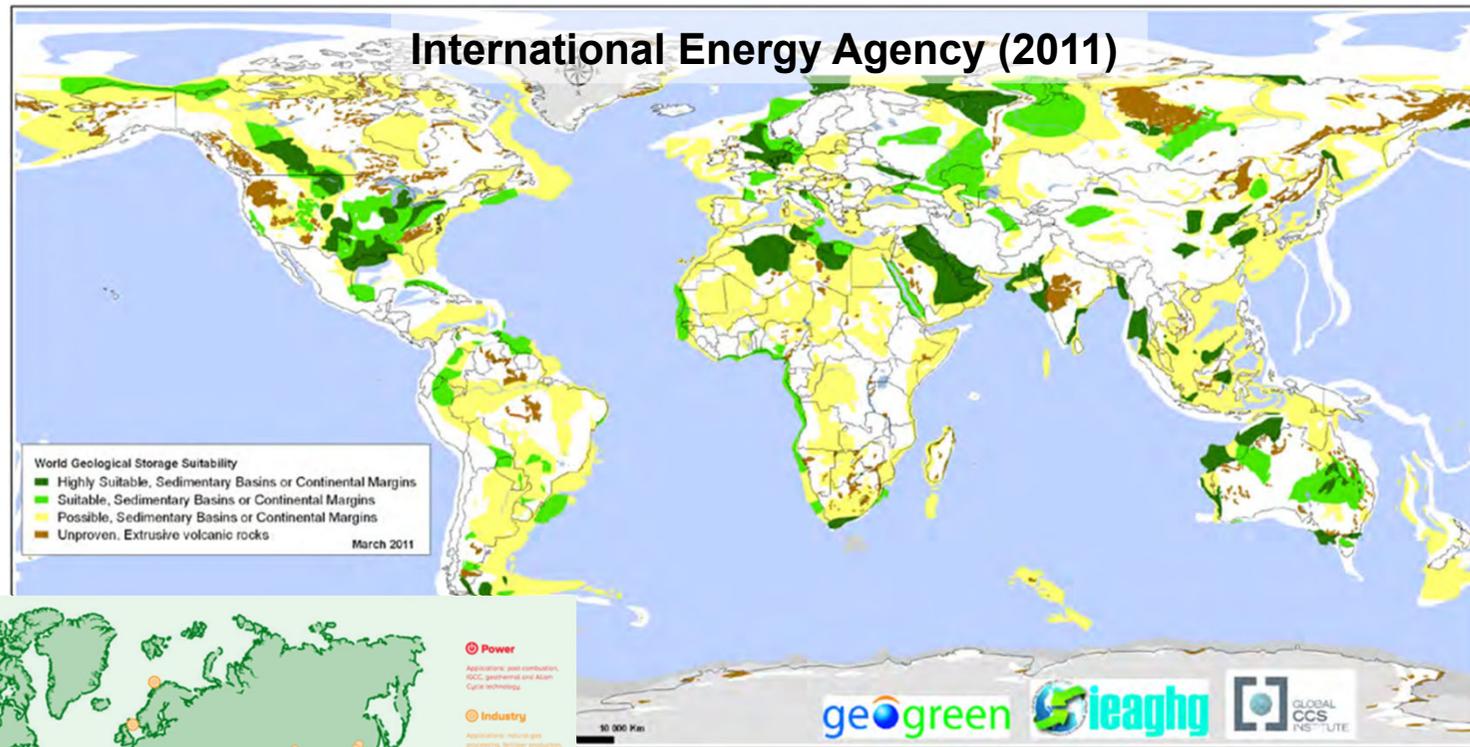
Funding



Challenge: To stop climate change, global annual CO₂ emissions need to go to zero!

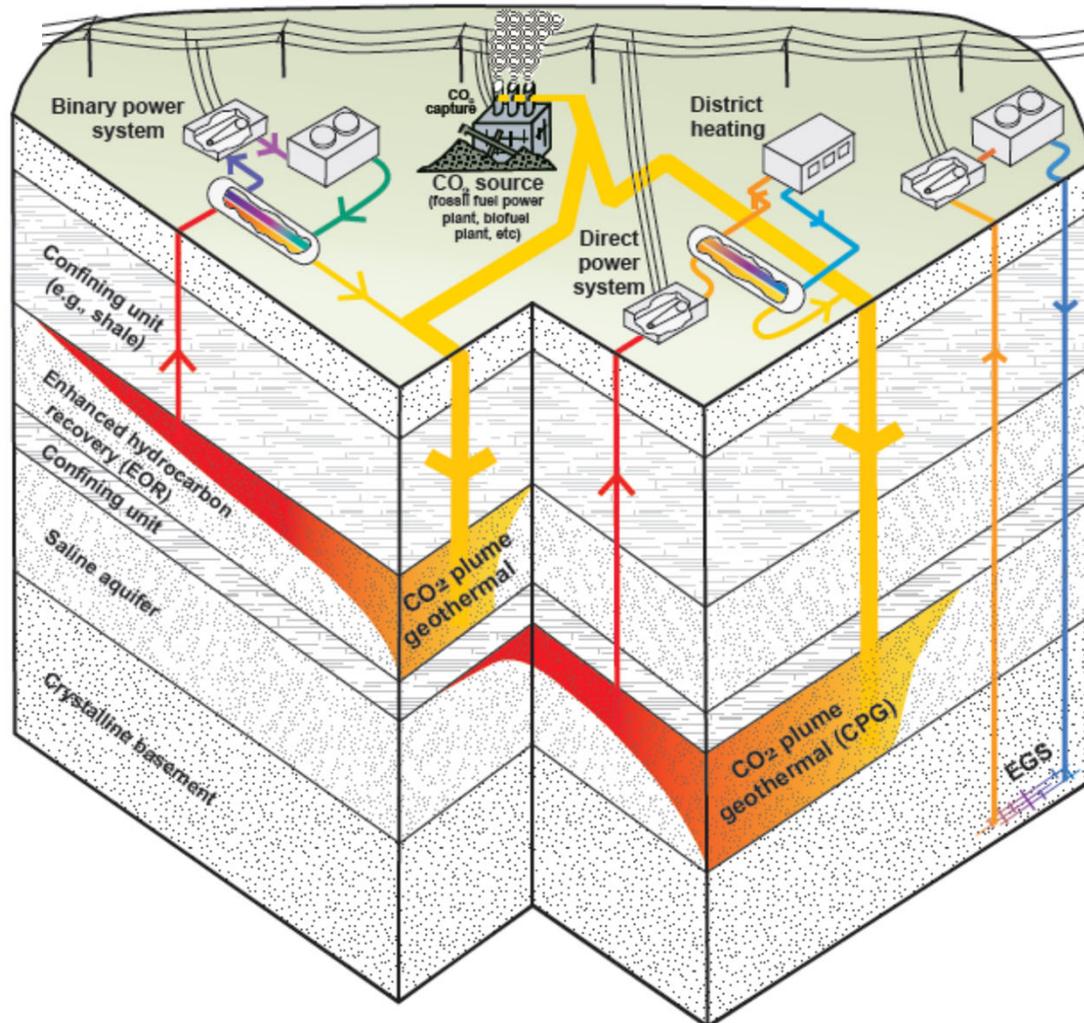


CO₂ is, and will be, sequestered in sedimentary basins

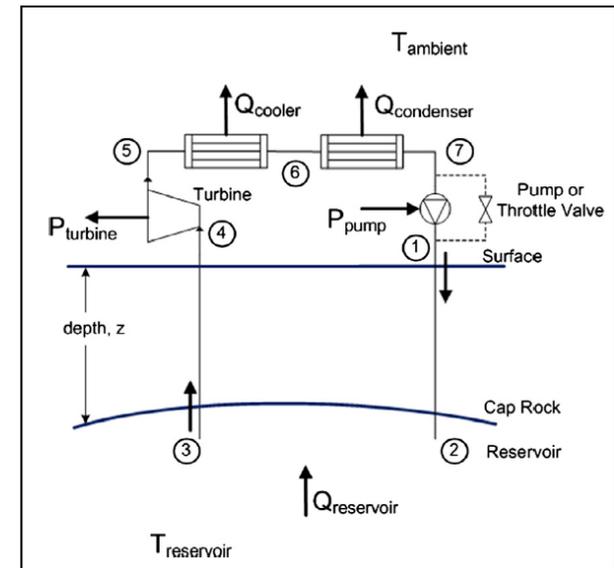


Many CO₂ storage reservoirs will be >2 km deep
 → Even for standard geothermal gradients of 35°C/km → >100°C

Combining CCS (or EOR/EGR) with geothermal energy extraction → CO₂-Plume Geothermal (CPG)

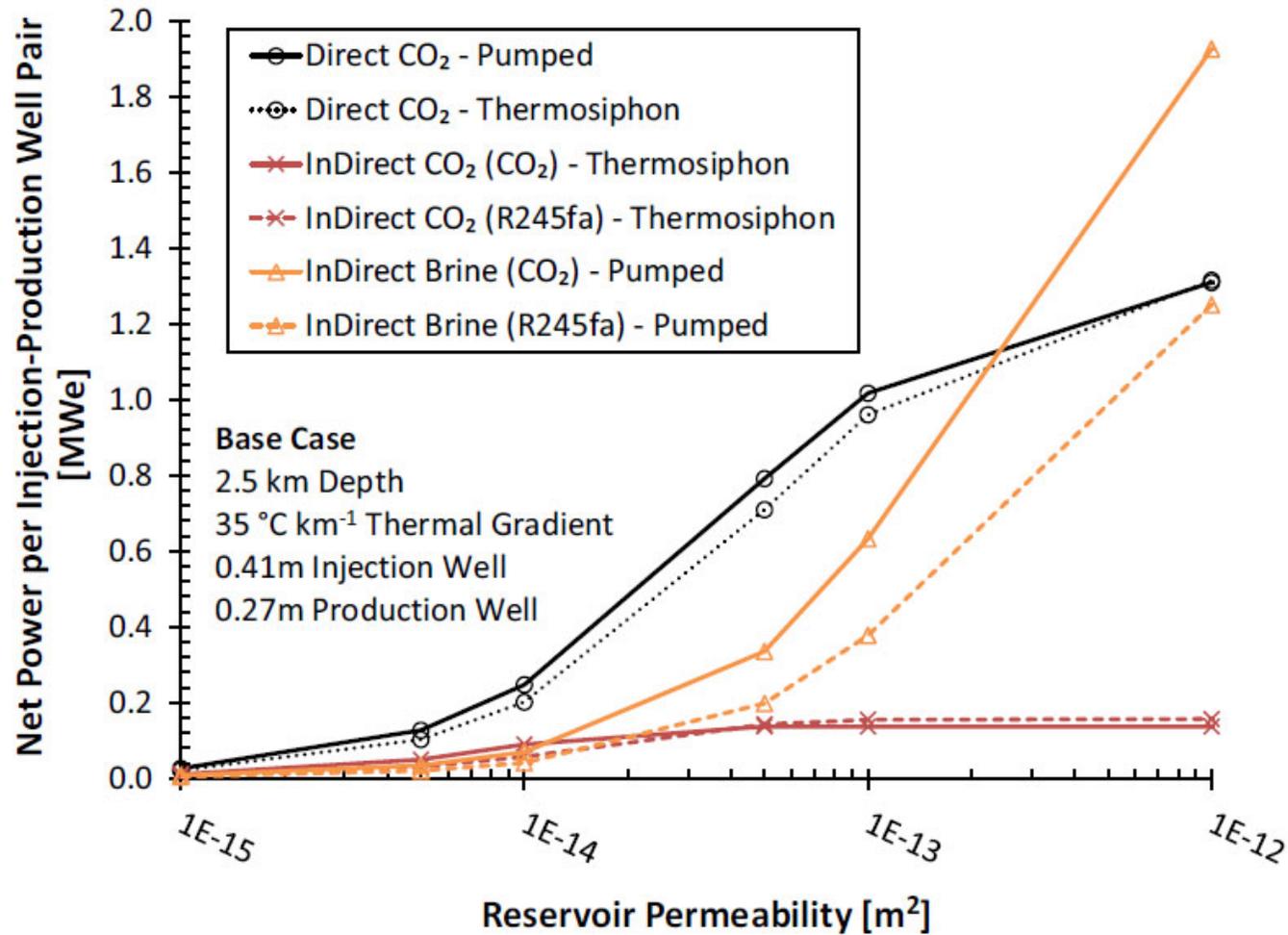


Direct CPG

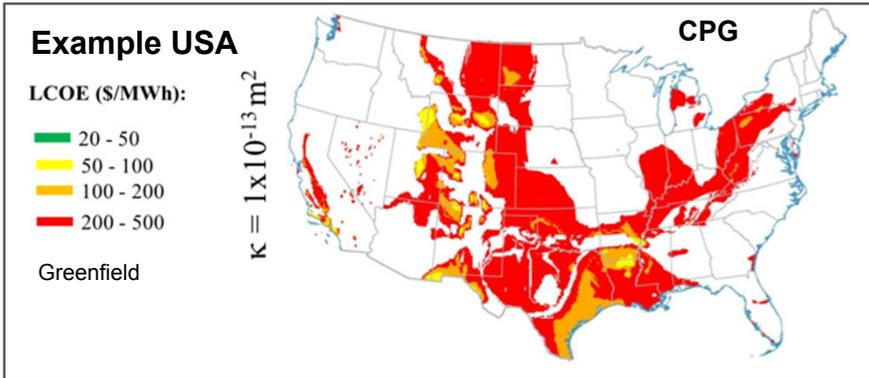


Randolph and Saar, 2011
 Saar et al., 2012
 Adams et al., 2014, 2015
 Garapati et al., 2015

Direct CPG generates 2-3 times net electric power compared to brine+ORC

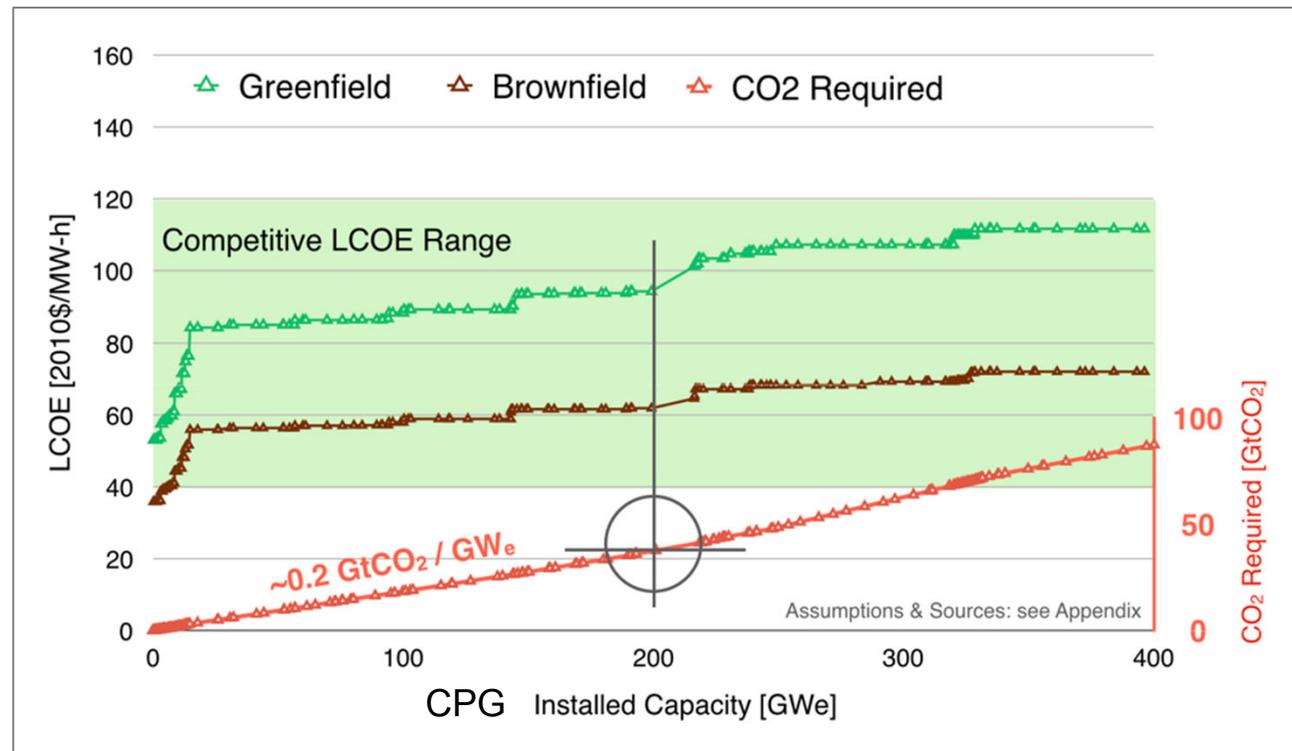


Expansion of geothermal resource base (e.g. USA)



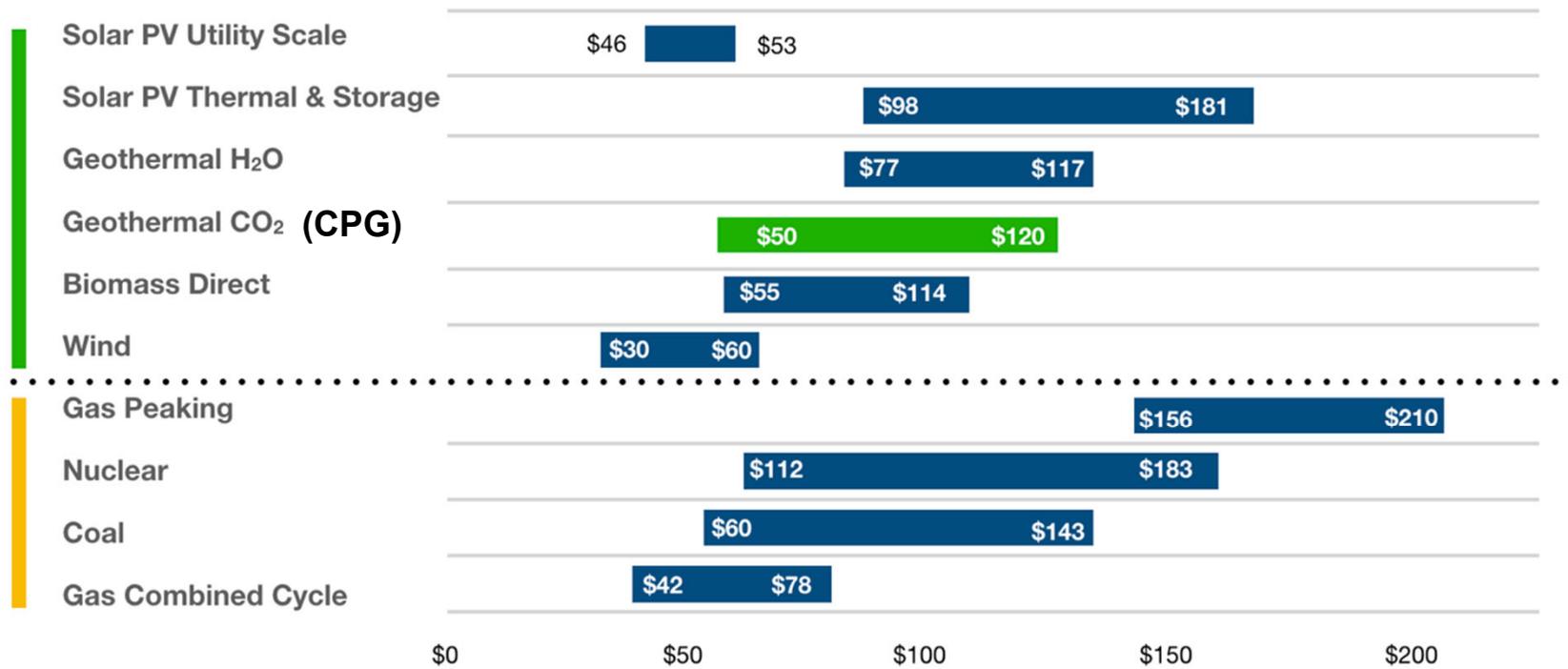
Cost-ordered available capacity

For Comparison
US: 1100 GWe Capacity



Levelized Cost of Electricity (LCOE)

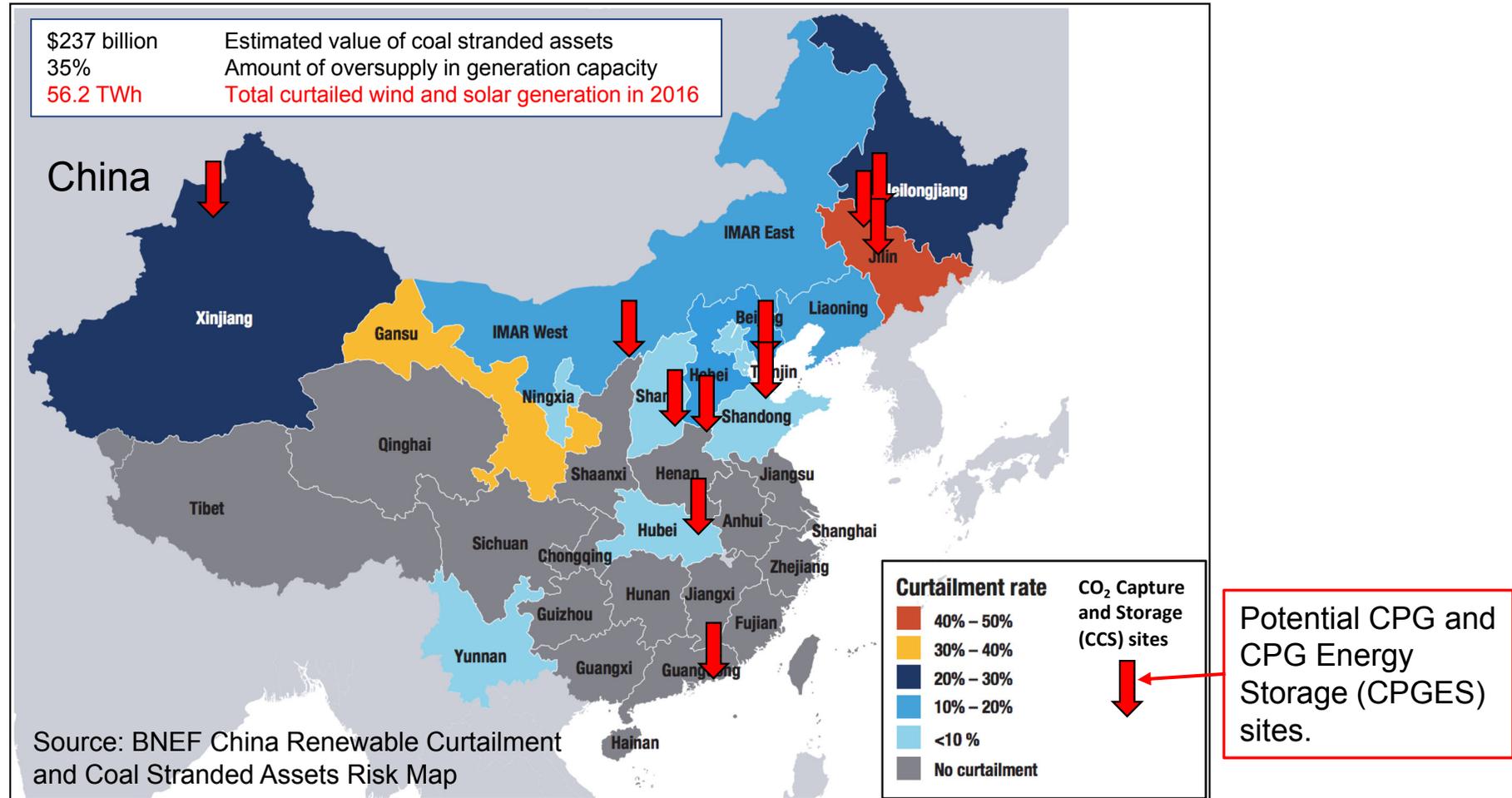
Measured as \$/MWh



Source: Lazard 2017, <https://www.lazard.com/perspective/levelized-cost-of-energy-2017/>

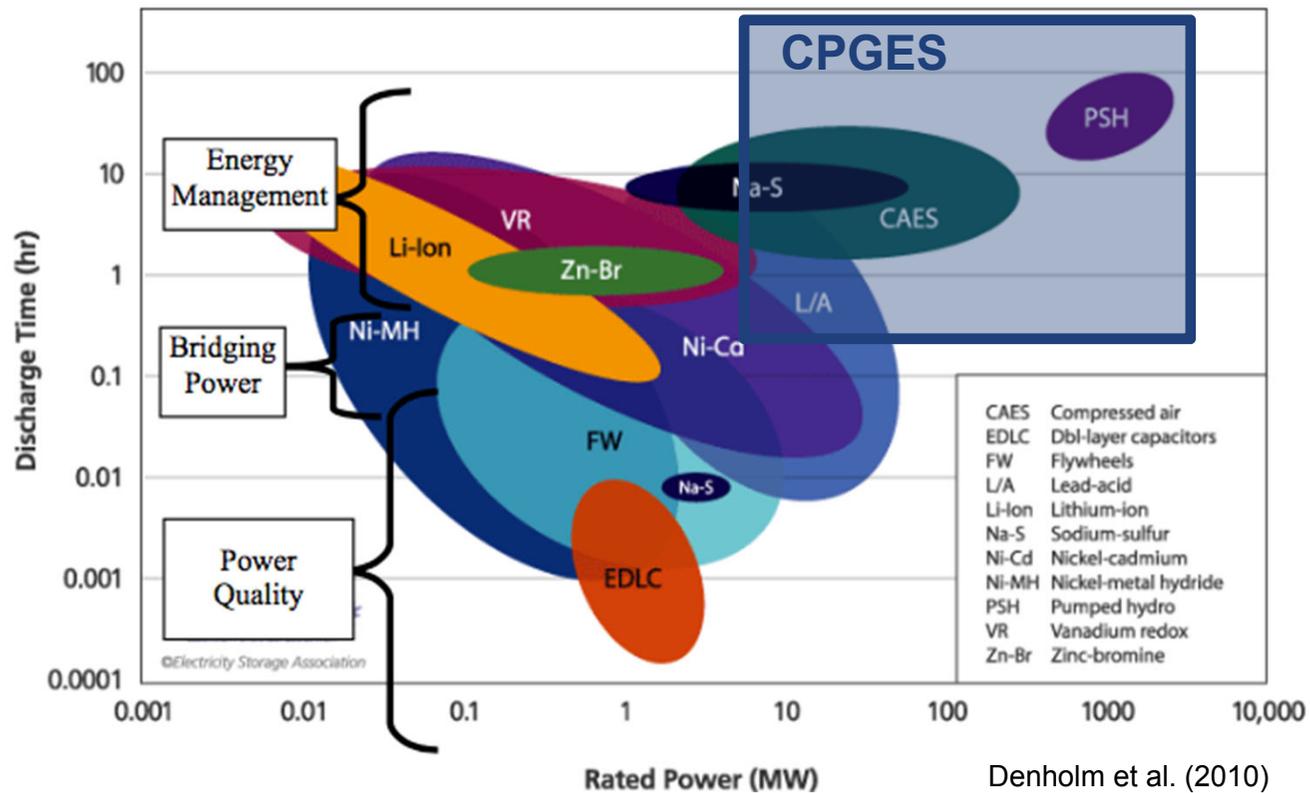
Wind and Solar Power Curtailment in China + CCS

Massive grid-scale energy storage needed worldwide!



CPG extended to Energy Storage (CPGES or Earth Battery)

CPGES or Earth Battery

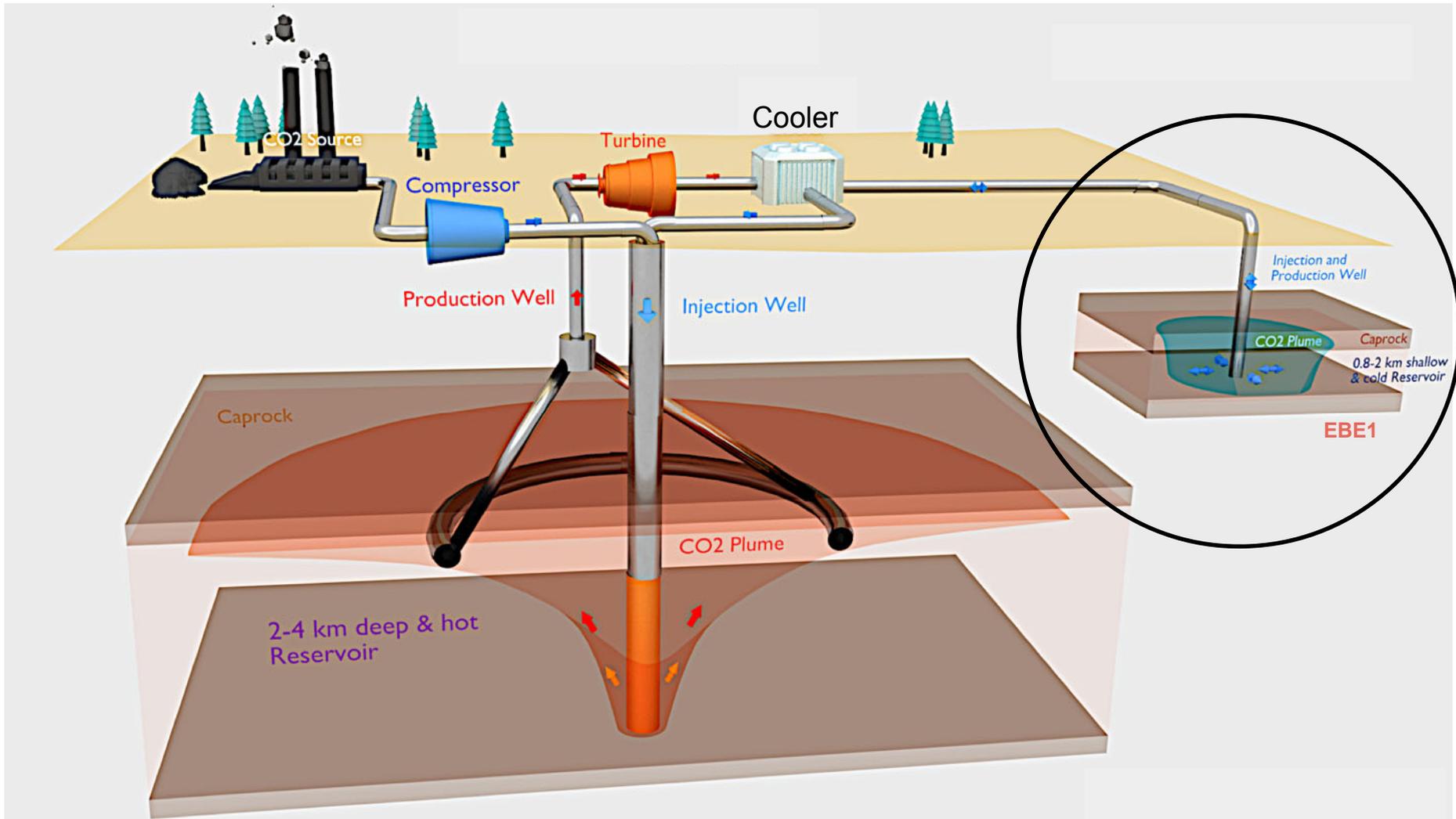


- CPGES stores energy from minutes to months and seasons
- CPGES stores energy in the GWh range

CO₂-Plume Geothermal (CPG) Power Plant

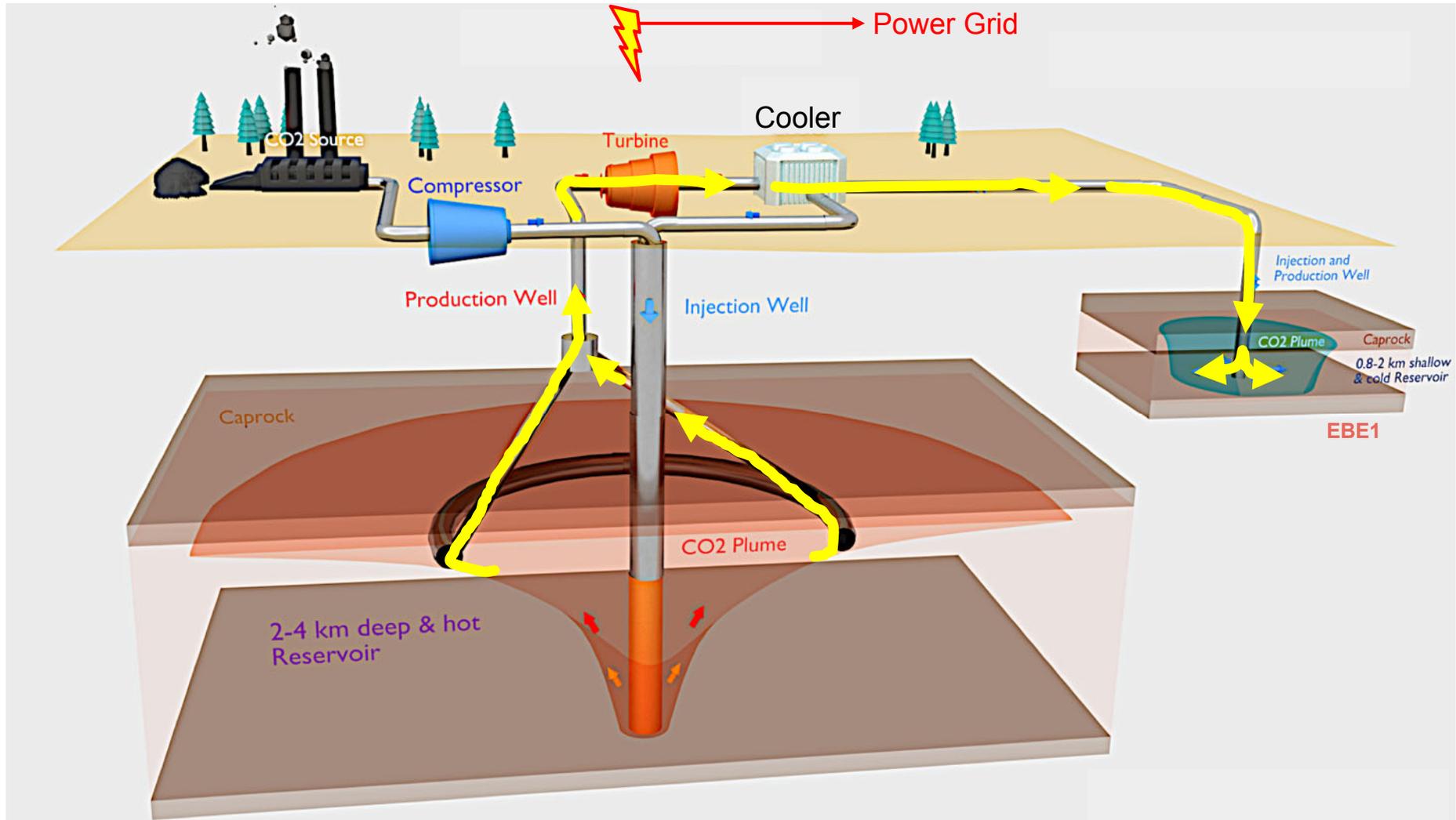


Energy Storage (EBE1) (CPGES or Earth Battery)



CO₂-Plume Geothermal (CPG) Power Plant

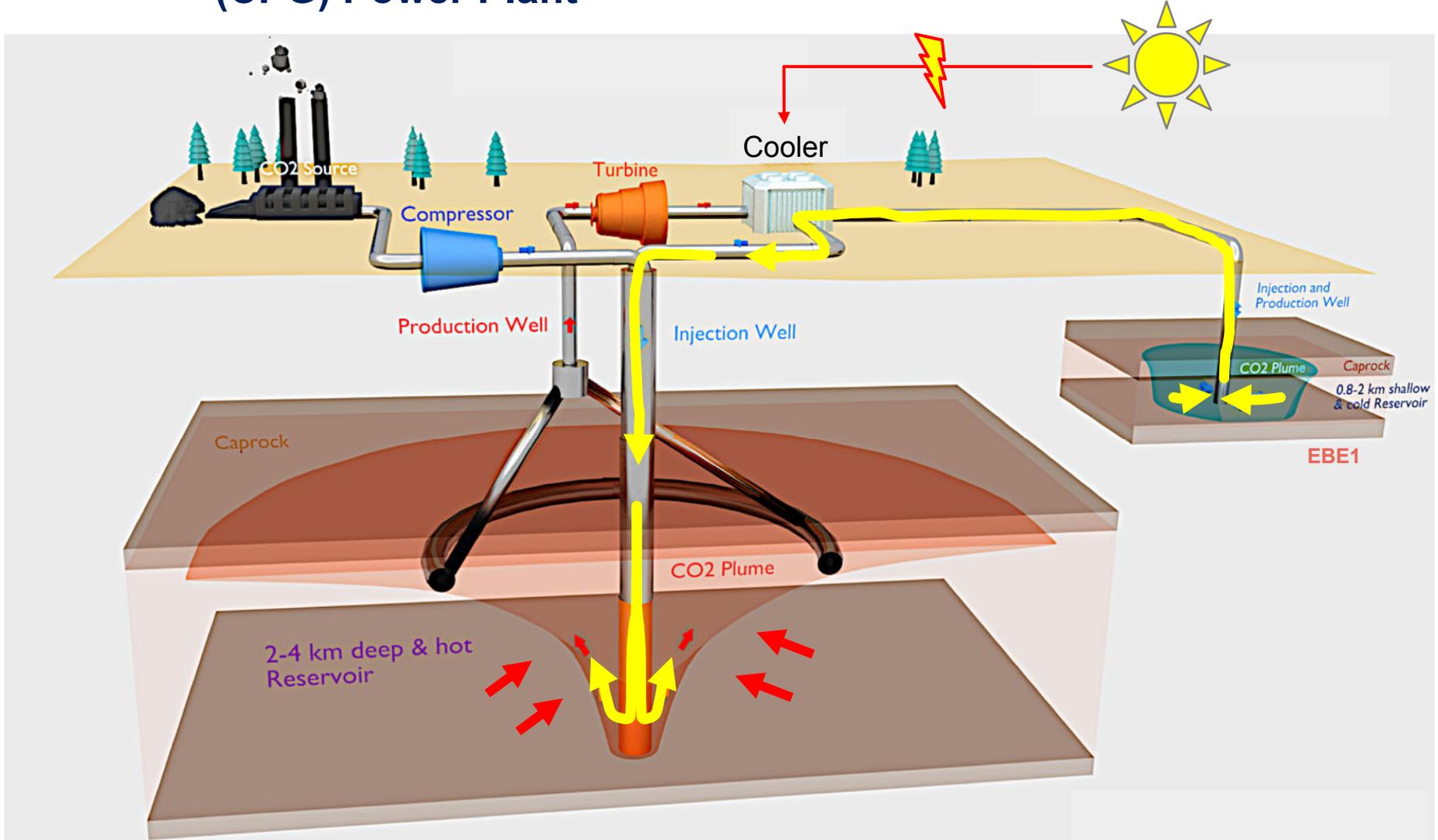
+ **Energy Dispatch Mode (CPGES or Earth Battery)**



CO₂-Plume Geothermal (CPG) Power Plant

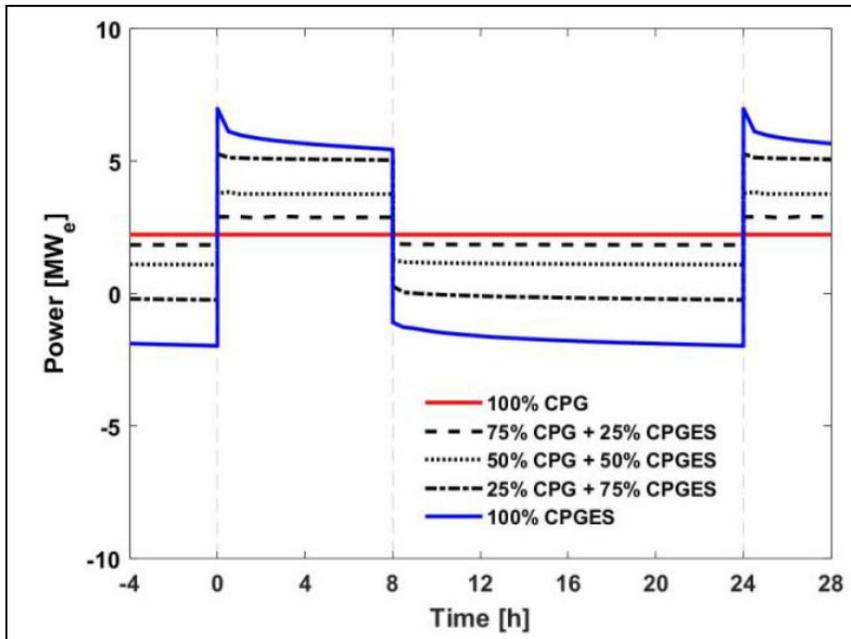


Energy Storage Mode (CPGES or Earth Battery)

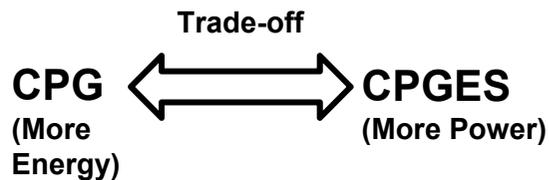
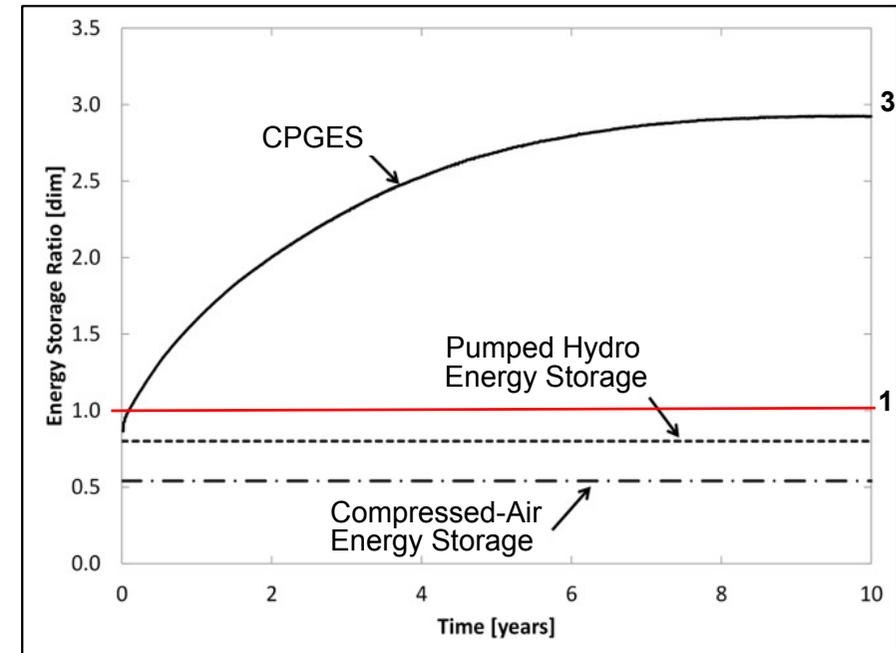


CPGES or Earth Battery (EBE1)

Can be varied from fully dispatchable to fully baseload.



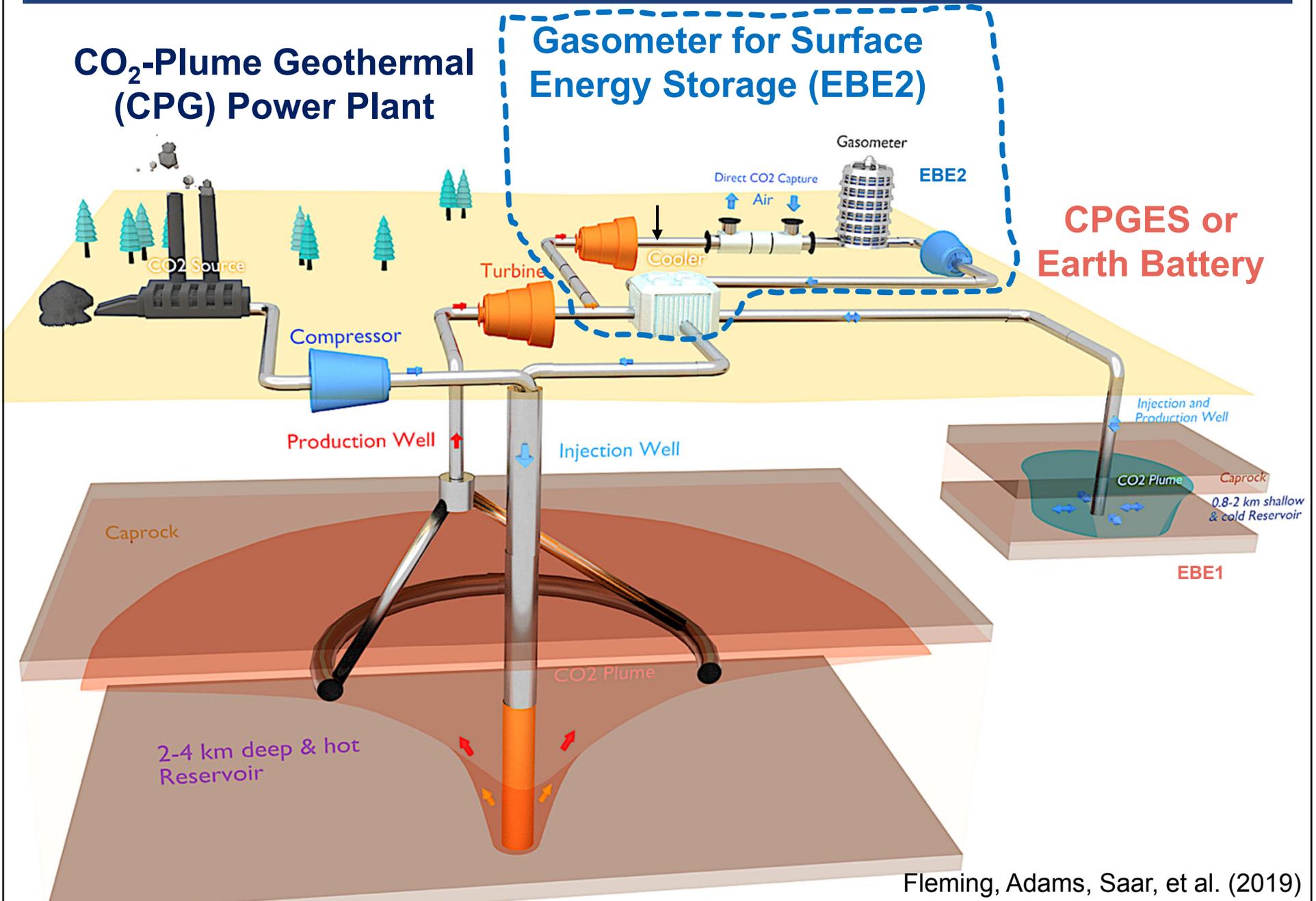
Has an energy storage ratio greater than one due to geothermal input.



CO₂-Plume Geothermal (CPG) Power Plant

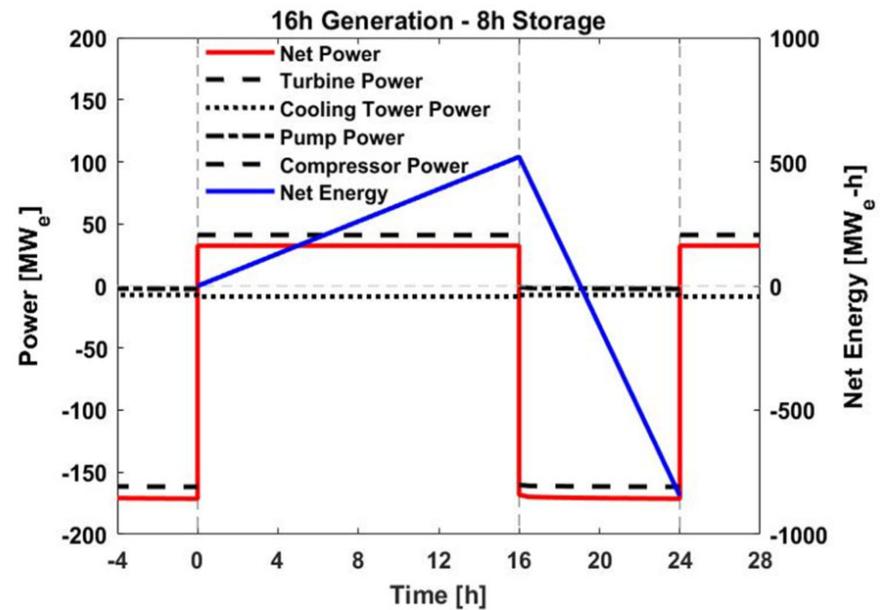
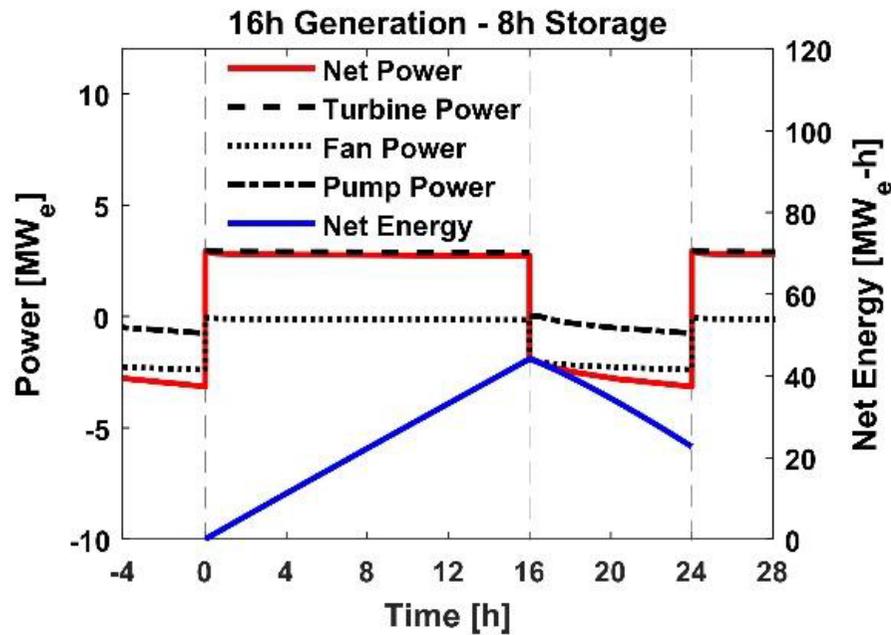
Gasometer for Surface Energy Storage (EBE2)

CPGES or Earth Battery

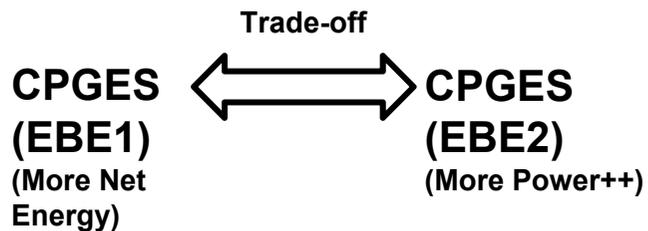


**Subsurface CPG
Energy Storage
(EBE1)**

**Gasometer CPG
Energy Storage
(EBE2)**



New ETH patent (EBE2)
10x generation power



The Geothermal Energy and Geofluids (GEG) Group (June 2019)

Institute of Geophysics, Department of Earth Sciences
ETH Zürich, Switzerland

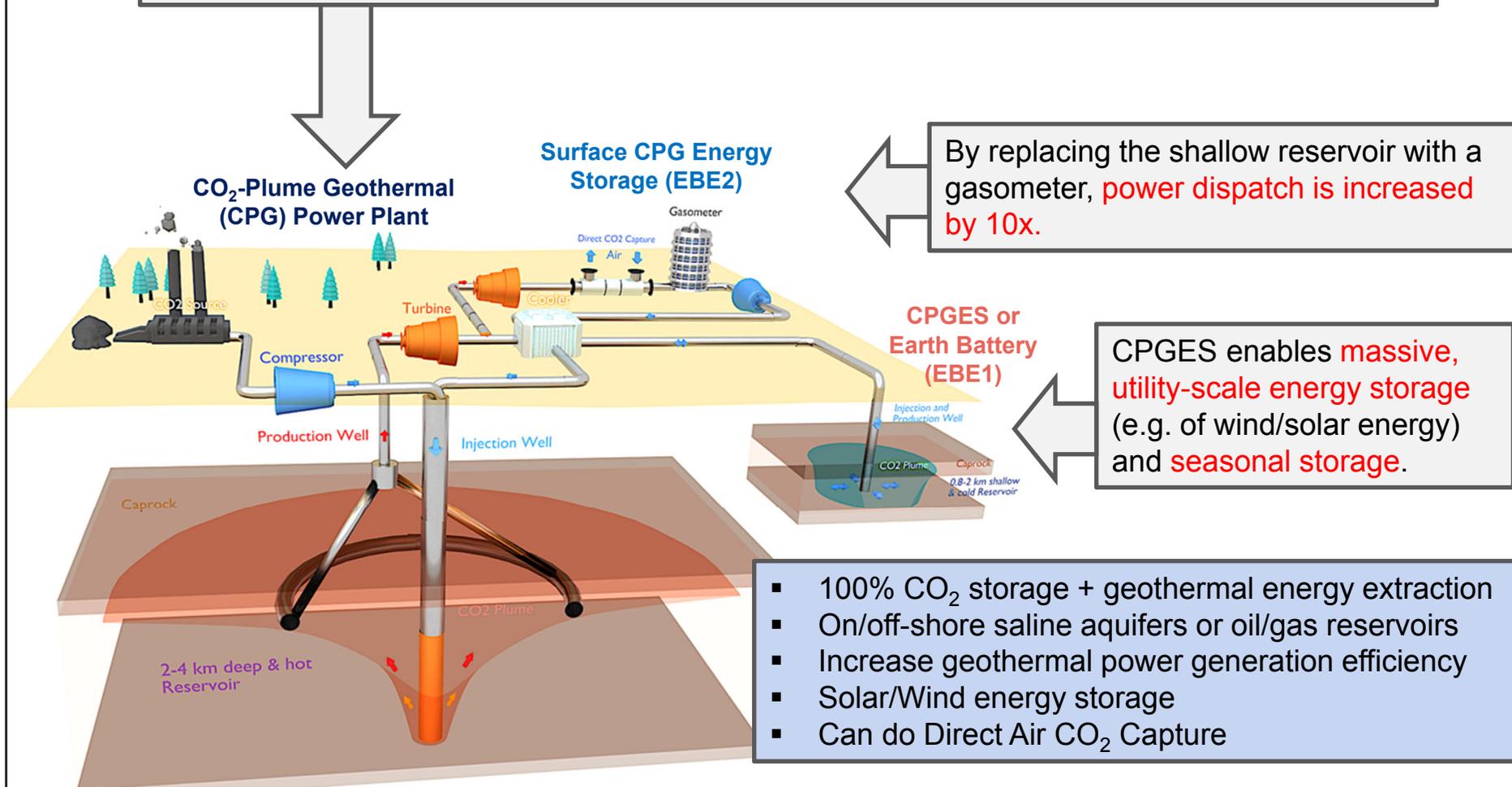


Research Areas: Subsurface fluid dynamics of multiscale, multiphase, multicomponent, reactive fluid (groundwater, CO₂, hydrocarbon) and heat energy transport during processes such as water- and CO₂-based geothermal energy extraction, geologic CO₂ storage, grid-scale energy storage, enhanced oil/gas recovery, and groundwater flow.

Summary

CO₂ can be used to **generate 2x to 3x the geothermal electricity as water.**

→ increases the geothermal resource base and provides reliable electricity.



Next step: Pilot Plant! Maybe Aquistore, CA, or France (Total) or Norway (Equinor) or China?