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Water Use and Large-Scale Geothermal Energy Production

Corrie Clark, Ph.D.

Environmental Science Division

Water/Energy Sustainability Symposium at the
GWPC Annual Forum 2009

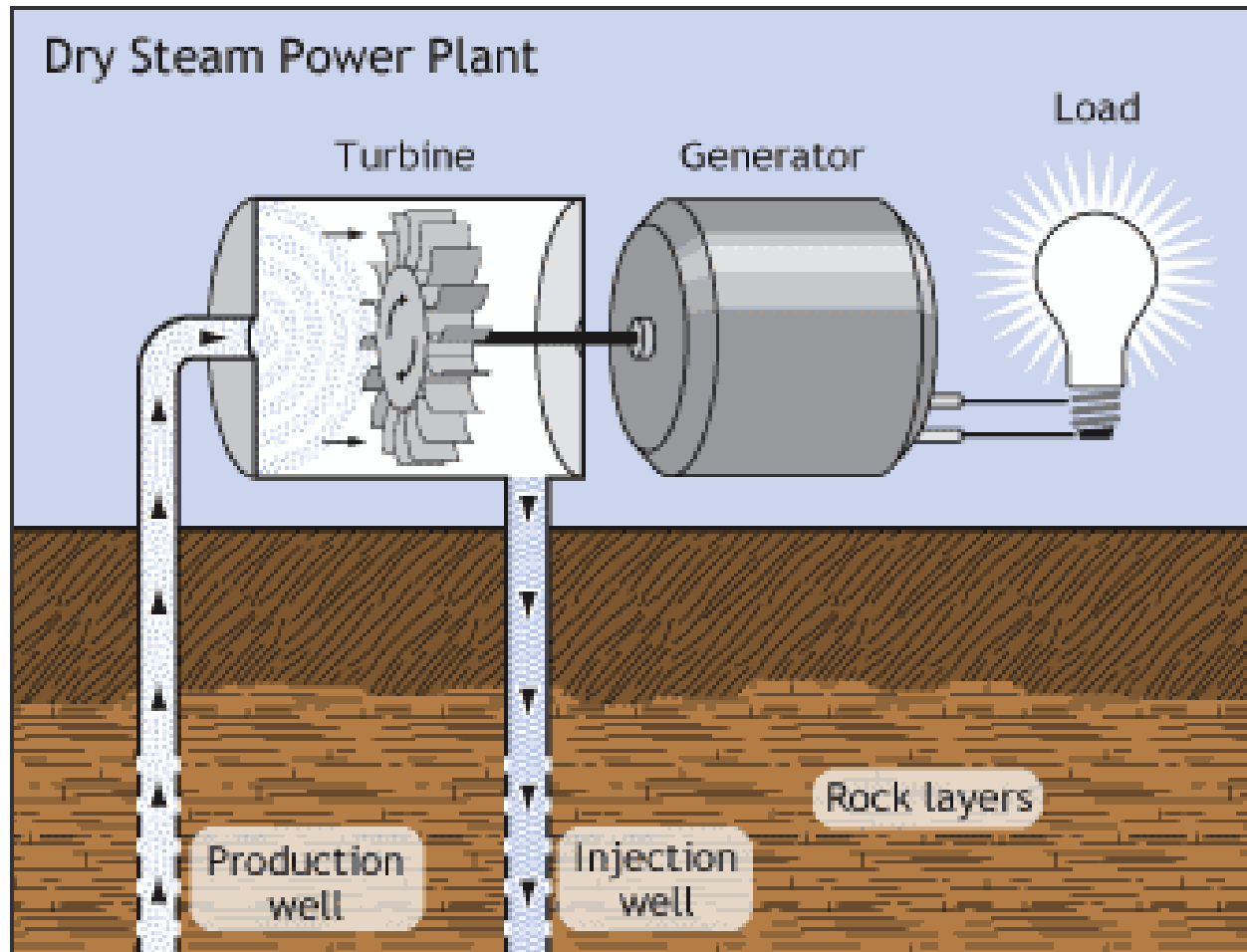
September 16, 2009

Agenda



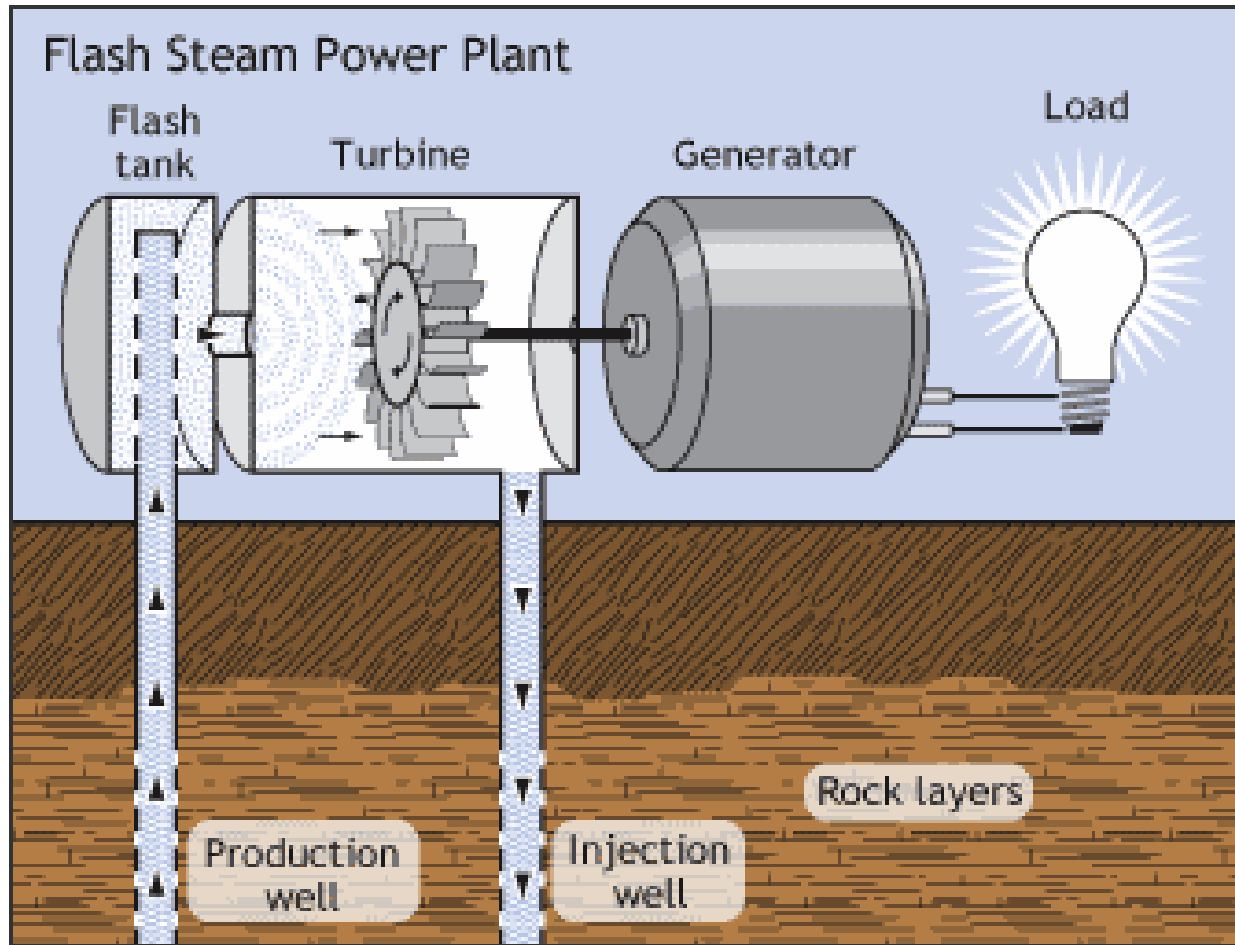
(DOE, 2008a)

Dry Steam Power Plant



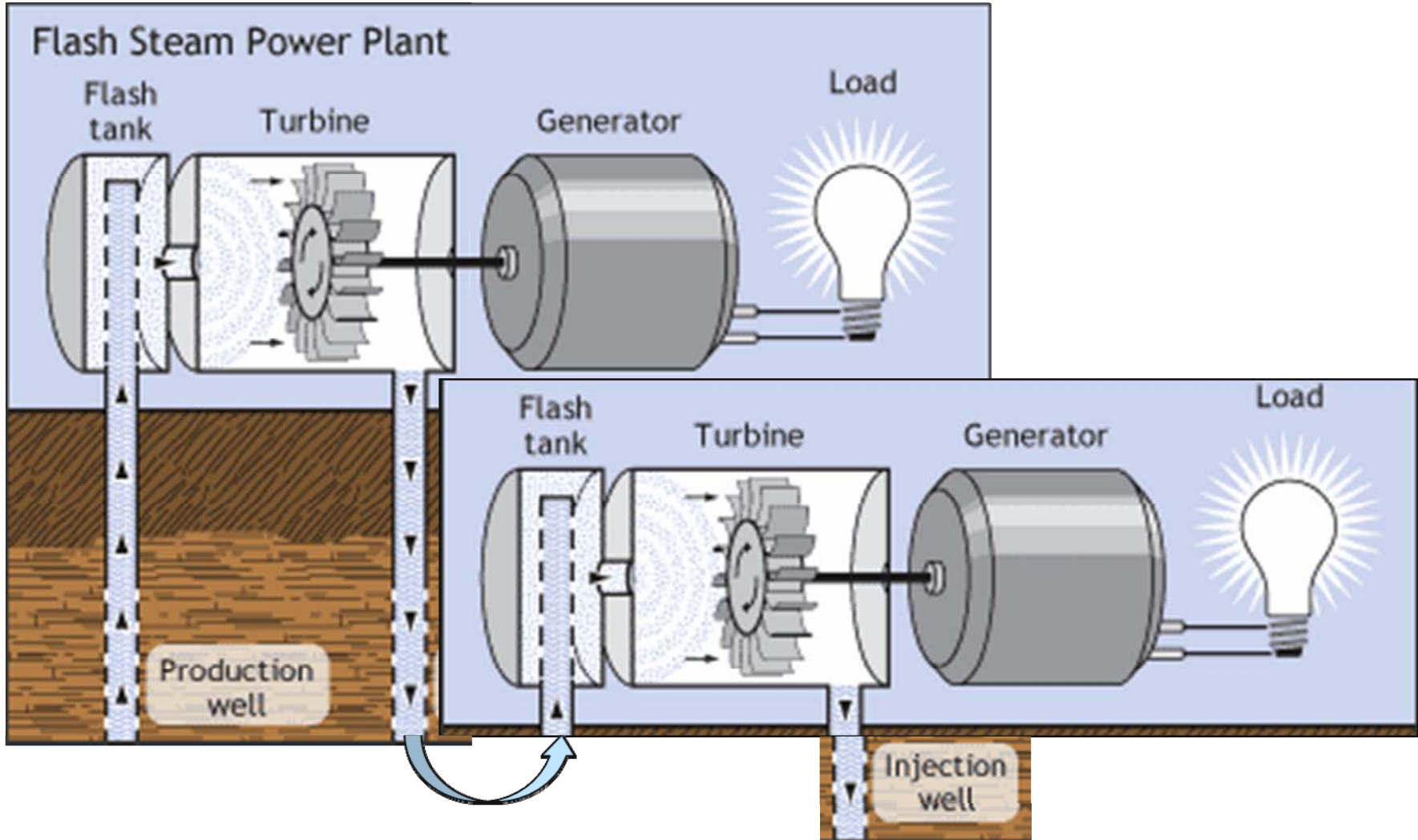
(DOE, 2008b)

Geothermal Power Plants



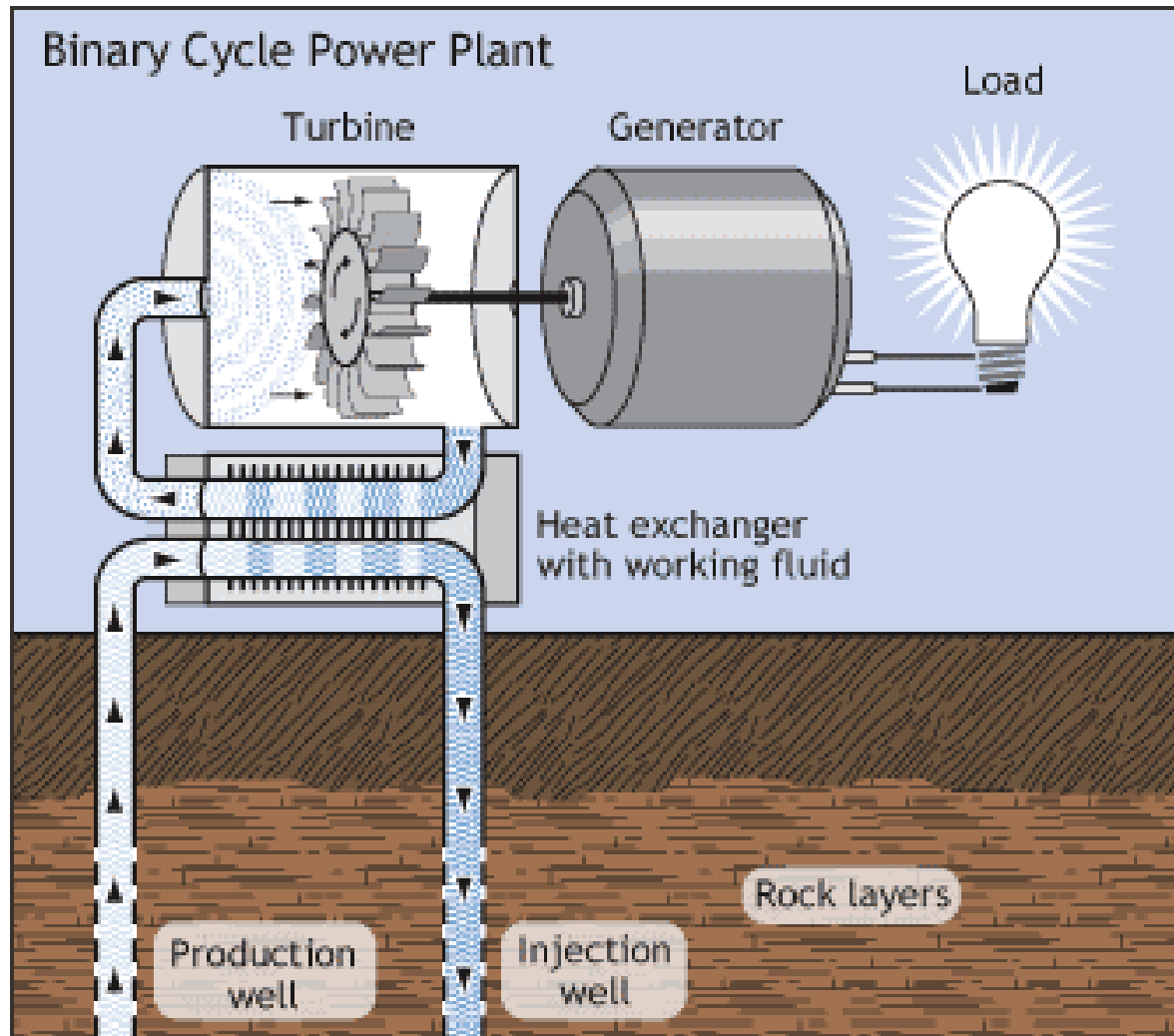
(DOE, 2008b)

Double Flash Steam Power Plant



(Modified from DOE, 2008b)

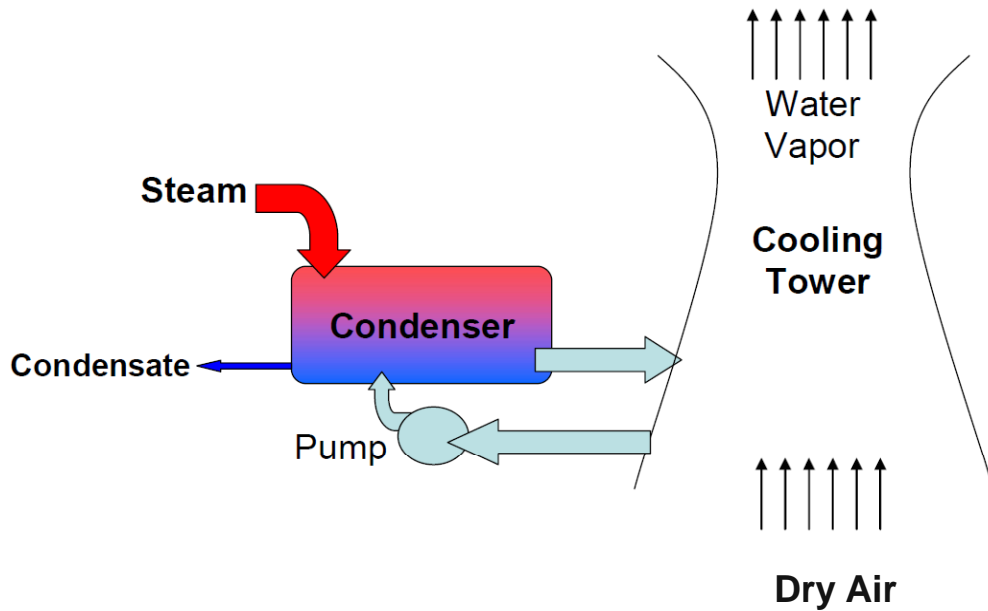
Binary Cycle Power Plant



(DOE, 2008b)

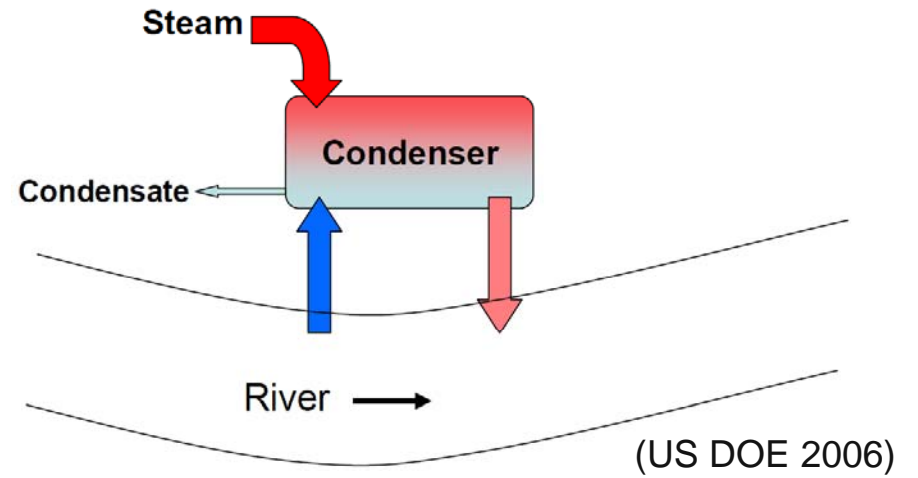
Cooling Systems

Dry Air Cooling

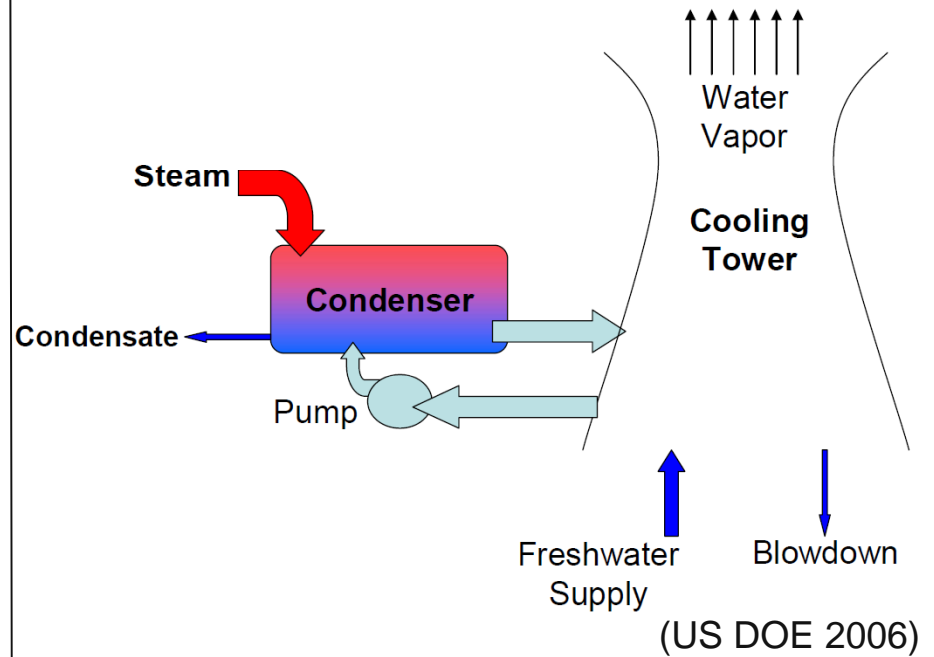


(Modified from US DOE 2006)

Open-Loop or Once-Through Cooling



Closed-Loop Wet Cooling

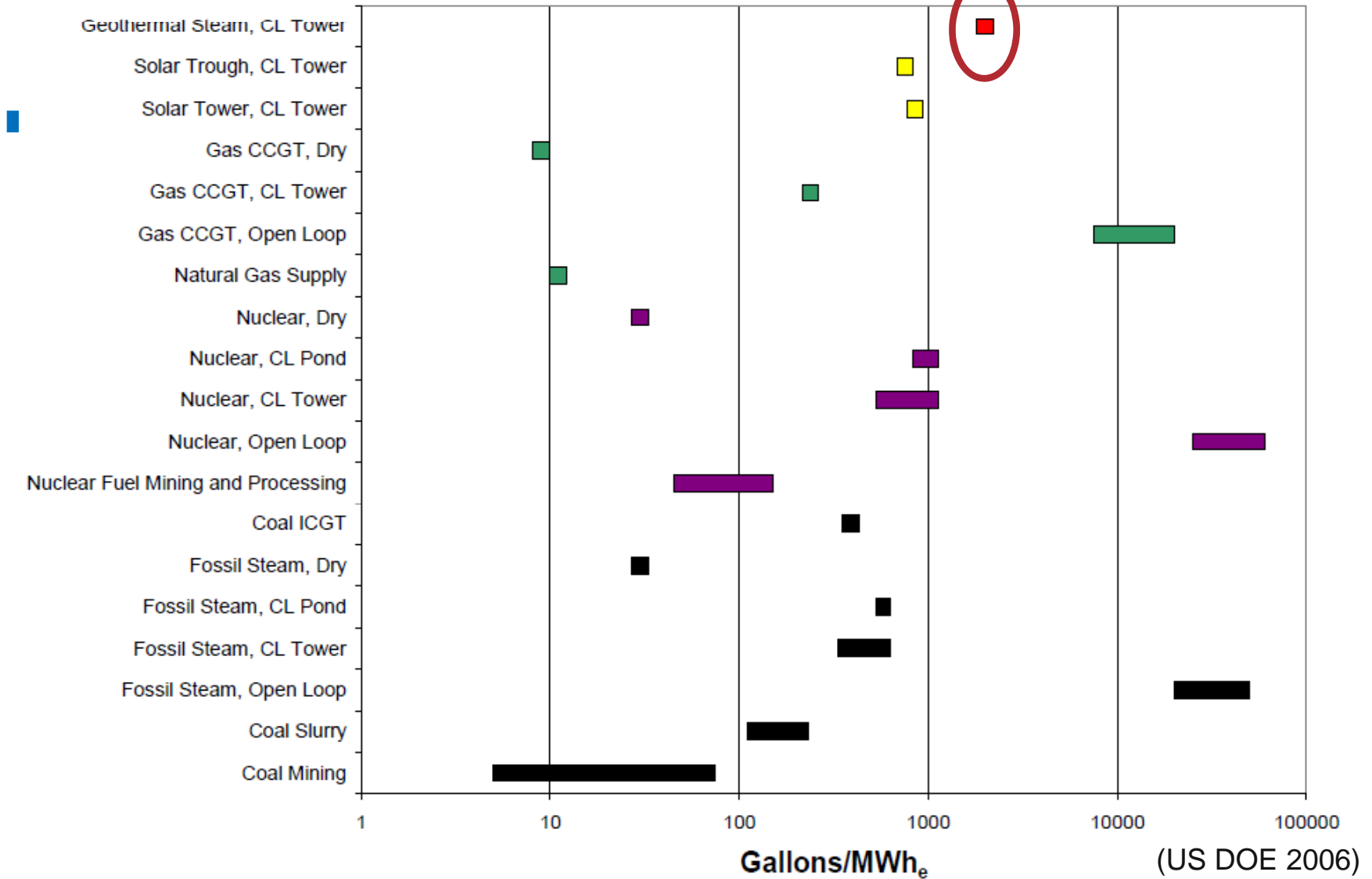


Cooling System Water Use

Water Use at Geothermal Plants	Withdrawal gal/MWhe		Consumption gal/MWhe		Sources
	Low	High	Low	High	
Cooling, open loop	0	14,265	0	65	Hagedoorn 2006, Dennen et al. 2007
Cooling, closed loop (wet)	0	4,499	0	4,499	Dennen et al. 2007
Cooling, dry air	0	0	0	0	Kagel et al. 2005

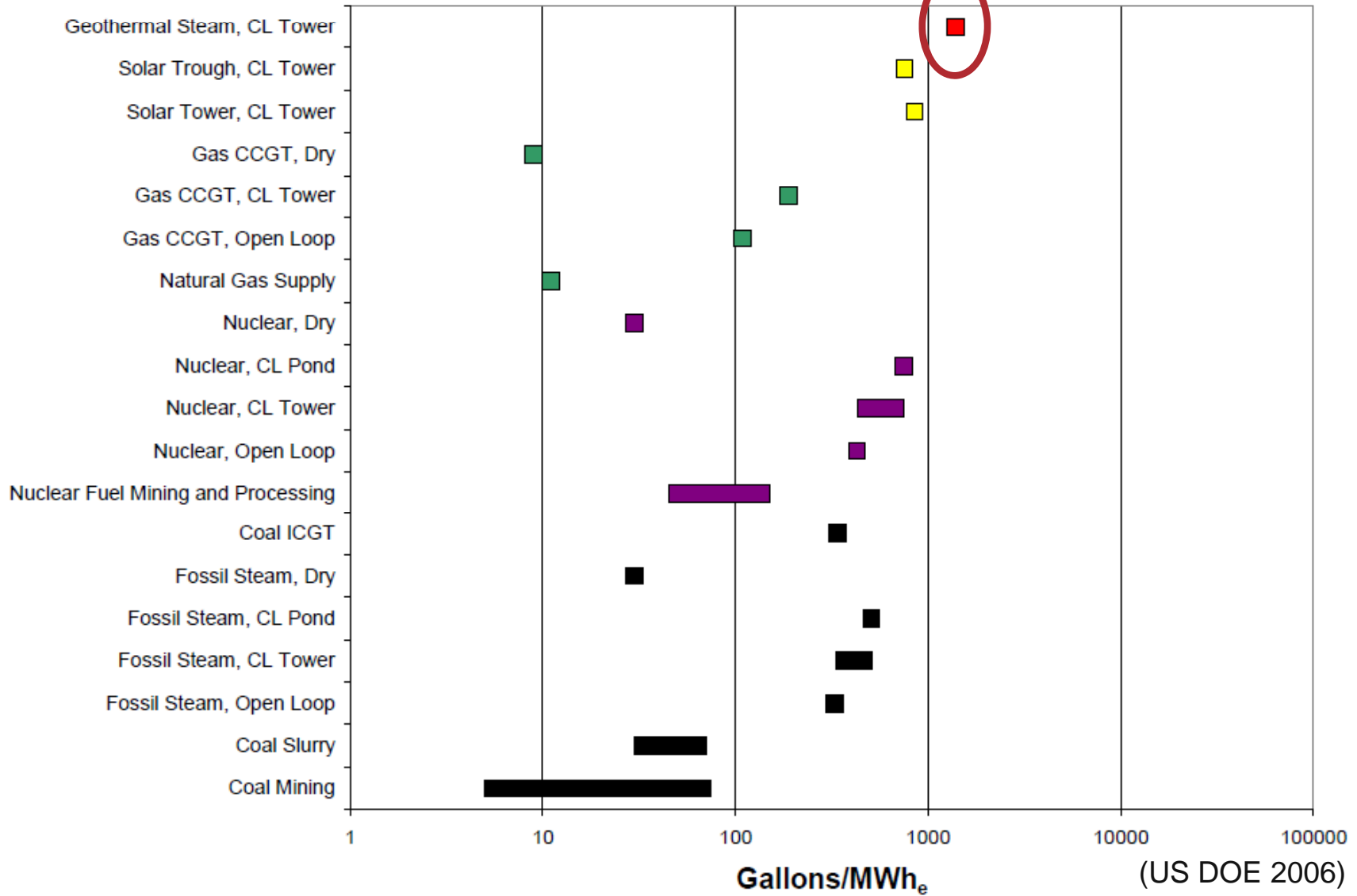
Water Use: Withdrawal

~2,000 gal/MWh_e



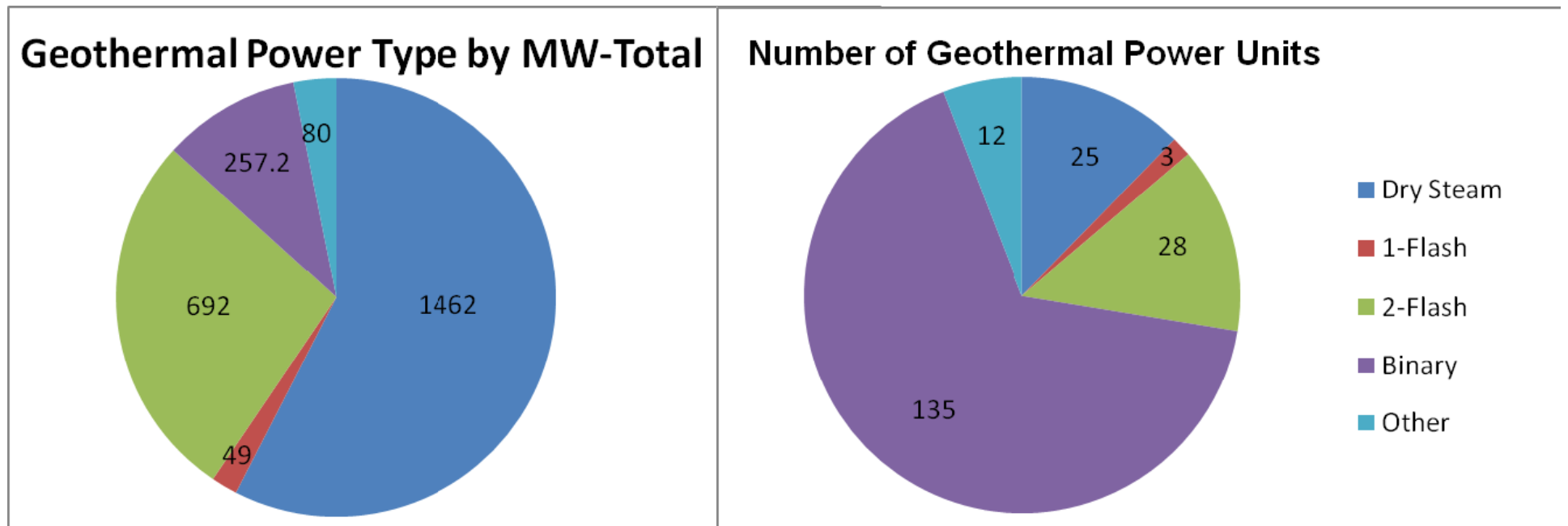
Water Use: Consumption

~1,400 gal/MWh_e



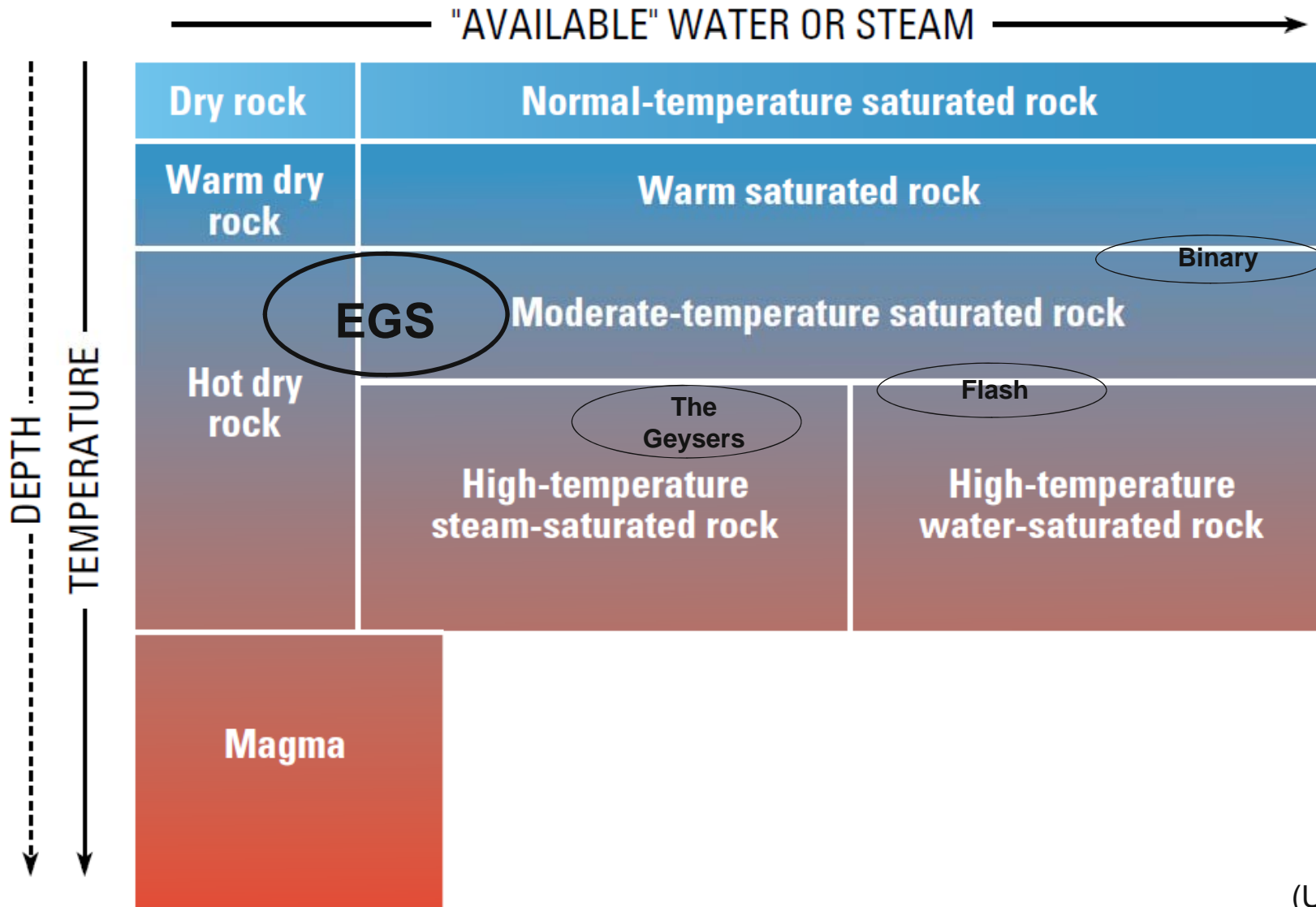
Limitation of Water Use Estimates

- Estimates provided in *Energy Demands on Water Resources* were from one geothermal power production site, The Geysers.
- The Geysers is unique.
 - It is the only known dry steam field in the US.
 - It is the largest geothermal power producer in the world.



Data as of May 2007 (DiPippo 2008).

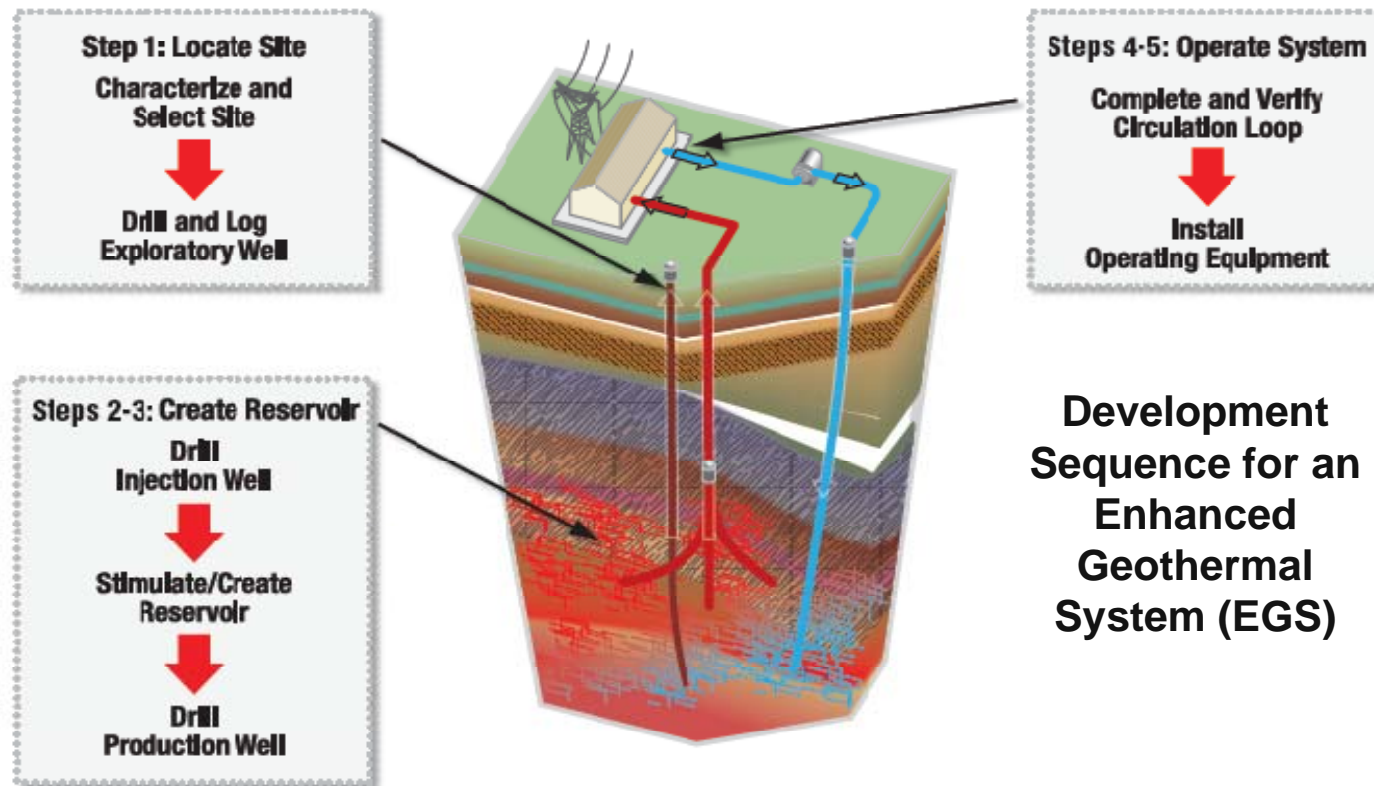
Geothermal Reservoirs



(USGS 2003)

Reservoir Creation and Water

- Water and muds are used during drilling to access the reservoir.
- Water and proppants stimulate and create the reservoir.
- Makeup water maintains pressure for successful operation.



(DOE, 2008c)

Water Sources

- Existing water in reservoir.
- Wastewater from nearby community.
 - The Geysers has two projects, the Lake County Effluent Pipeline and the Santa Rosa Geysers Recharge Project.
- Surface water from nearby freshwater or saline water sources.



(DOE, 2008a)

Water Quality

- Water quality is primarily influenced by the following:
 - Characteristics of the reservoir,
 - Technologies used to produce power,
 - Chemicals used in operations, and
 - Characteristics of any supplemental water sources.
- Hot water systems are often characterized by high amounts of chlorides, silica, boron, and arsenic.
- Vapor-dominated systems usually have lower levels of common metal chlorides and lower concentrations of silica.

Water Quality: Water Types

- Alkali chloride waters
 - Contain high sodium and potassium chloride contents.
 - Typically found in deeper, hotter systems.
- Acid sulfate waters
 - Have a low chloride content.
 - Constituents leach mainly from surrounding rocks.
- Acid sulfate-chloride waters
 - Exhibit properties of both alkali chloride and acid sulfate waters.
- Bicarbonate waters
 - Have variable sulfate concentrations, high sodium concentrations, and neutral pH.
 - Common at great depths within metamorphic or sedimentary rocks.

Summary

- Water use is dependent upon the resource characteristics, the power generation technology, and the cooling technology.
- Available consumption information for geothermal does not currently include injection for liquid dominated systems.
- Further understanding of consumptive losses to the resource are needed for a comprehensive understanding of water requirements. This is especially important in the development of EGS.

Corrie Clark
Argonne National Laboratory
955 L'Enfant Plaza, SW Suite 6000
Washington, DC 20024-2112
ceclark@anl.gov
(202) 488-2419

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