TEXAS A&M UNIVERSITY SCHOOL OF LAW

Owning Heat: Property Rights in Geothermal Resources

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Montana Legislature

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Issue

How to facilitate private and public development of geothermal energy resources in a manner that balances public stewardship and private enterprise

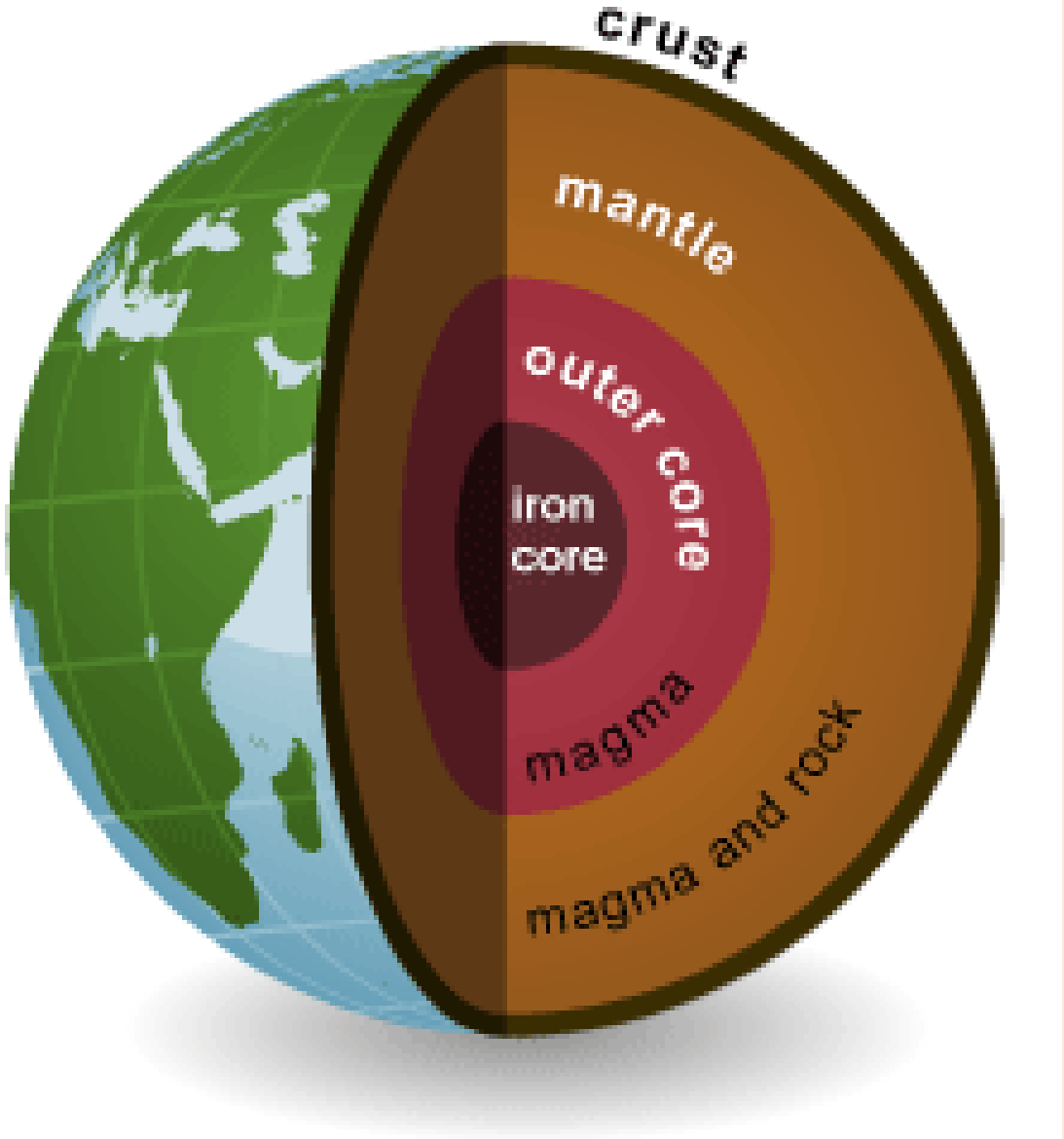
Underlying Premises

- Absent clear rules for ownership/property in geothermal energy, commercial and public investment in this promising, clean, renewable energy resource in the United States will remain limited
- Definition of ***ownership*** of geothermal resources depends on the unique characteristics of the resource

Outline

- What is Geothermal Energy
- Potential of Geothermal Energy
- Geothermal Energy in a Property Context
- Way forward?

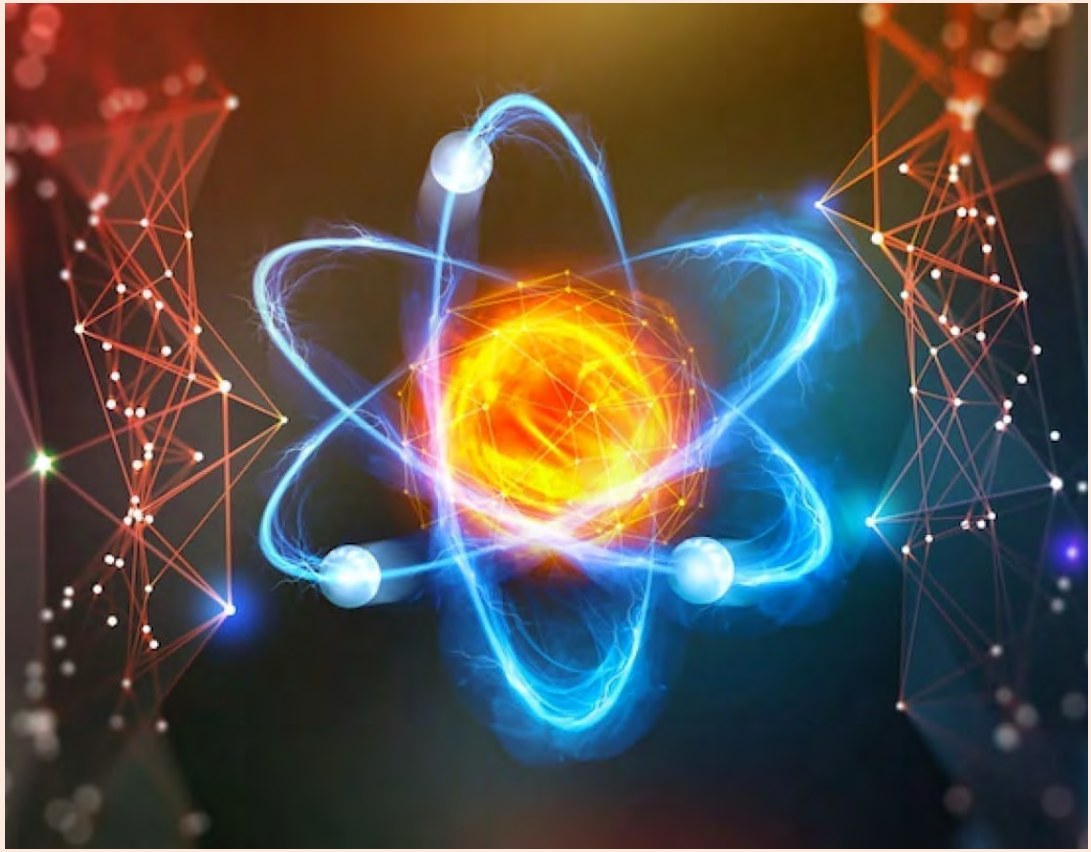
What is Geothermal Energy?



- Geothermal energy comes from the heat within the Earth. The word geothermal comes from the Greek words *geo*, meaning *earth*, and *therme*, meaning *heat*.
- Geothermal energy is generated in the Earth's **core**, nearly 4,000 miles (6,400 km) beneath the Earth's surface.
  - Residual primordial heat that originated when the planet was formed over 4.5 billion years ago
  - Radiogenic heat energy resulting from the decay of radioactive isotopes (s.a., uranium, thorium, rubidium, and potassium)
- Heat gradient = appx. 25° C for each kilometer of depth, or 1° F per 70 feet (~6,000° C / 10,832° F at inner core; ~14° C / 57° F at the Earth's surface)

What is Geothermal Energy?

- **Non-corporeal** – non-physical, non-tangible resource
- **Fugacious** – cannot be contained or confined
- **Not usable directly** – Exist as thermal energy; must either be transferred into a physical medium that can contain the heat (e.g., water and steam), or be converted into another, more readily useable energy form (e.g., electrical energy)
- **Impact** – Extraction or injection (e.g., "dumping") of "warmer" or "colder" thermal energy can affect the reservoir's thermal energy content within a radius of the extraction/injection site
- **Sustainability** – While thermal energy is renewable, it is not unlimited; extraction in excess of natural replenishment can reduce reservoir temperature



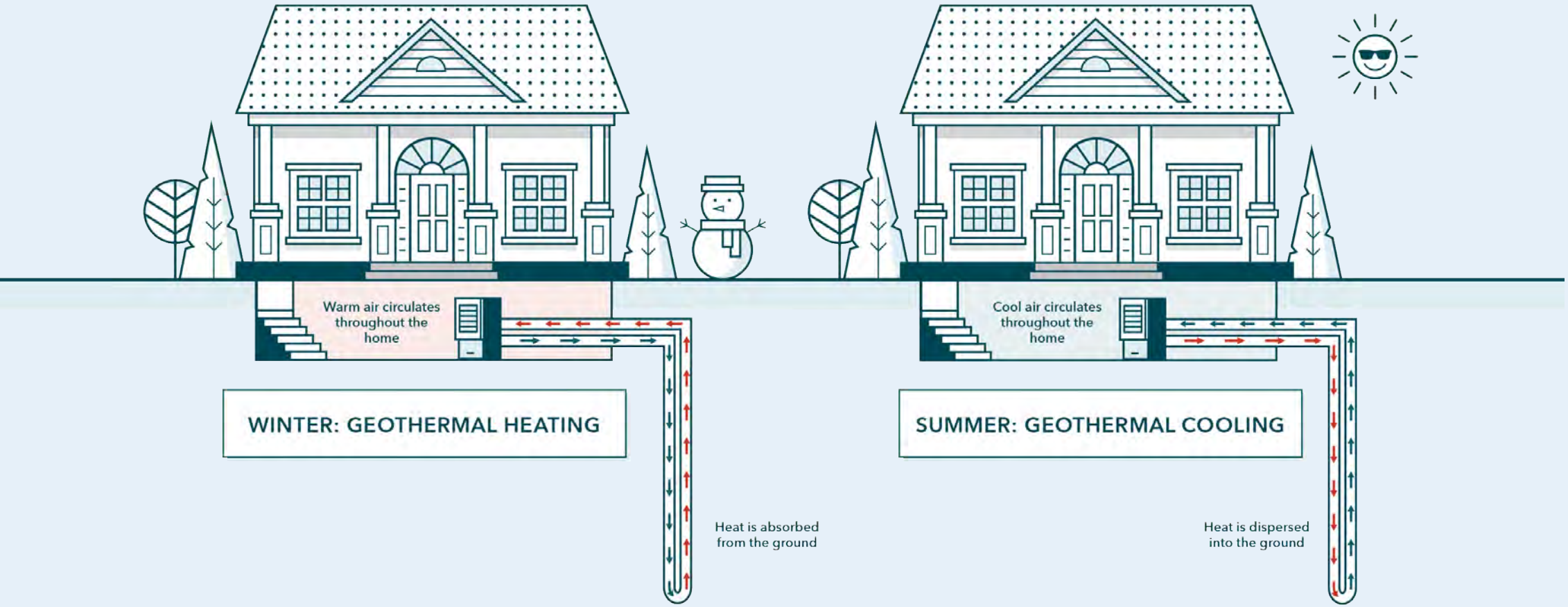
So, how exactly can you "own" thermal energy?

Geothermal Energy Potential

- Within the top 10,000 meters (~33,000 feet) of the surface alone, the Earth is estimated to hold and sustain 50,000 times more heat energy than contained in all of the world's oil and natural gas resources combined
- Amount of heat energy continuously released from the Earth at its surface is estimated at 44 to 47 terawatts (TW) of energy. In comparison, in 2021, the total installed power capacity in the US was 1.177 TW
- Nearly limitless and continuously replenished, with a lifespan estimated in the billions of years
- Available literally everywhere below the Earth's continental and oceanic crustal surfaces (if you dig deep enough …)
- Results in near-zero carbon emissions, making it a potential leading source of clean, renewable energy

Geothermal Energy Potential: Indirect Use

Geothermal Heat Pumps

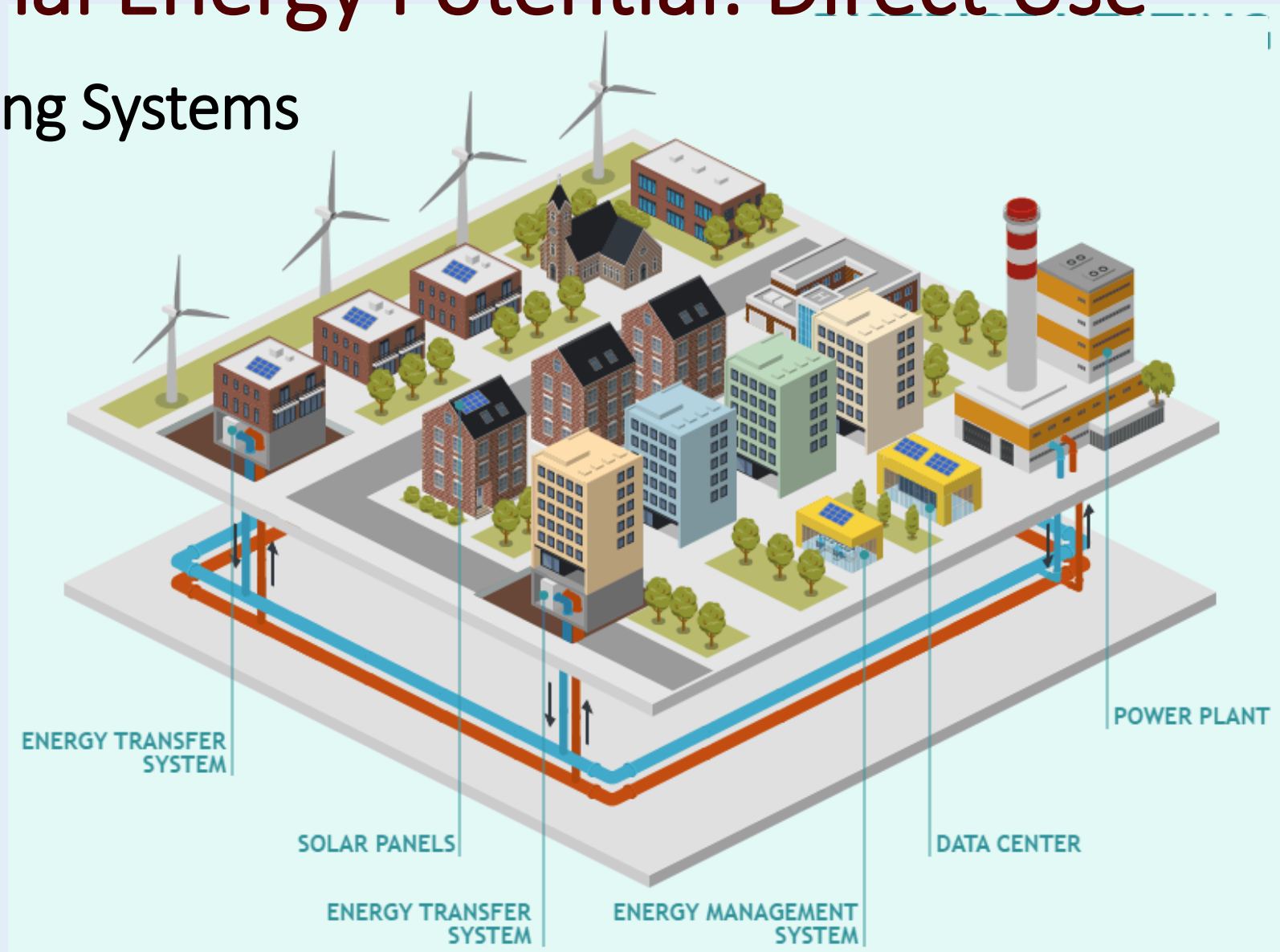


Low temperature (40-90°F / 4.5-32°C) geothermal energy can be used indirectly through the use of heat pumps for heating and cooling homes and buildings

David Roberts, The Earth itself could provide carbon-free heat for buildings, Vox, Nov. 13, 2020, https://www.vox.com/energy-and-environment/2020/11/13/21537801/climate-change-renewable-energy-geothermal-heat-gshp-district-heating

Geothermal Energy Potential: Direct Use

District Heating Systems

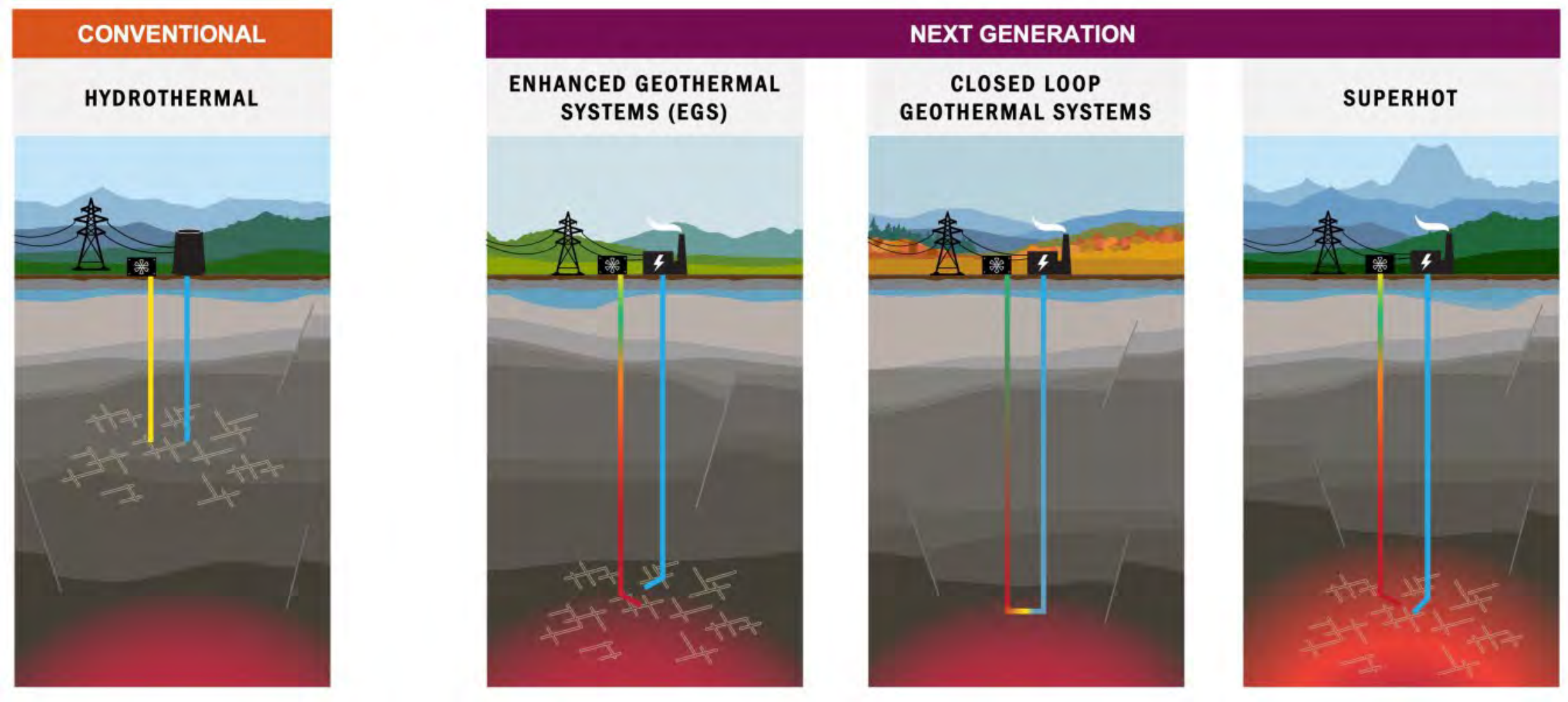


Low to medium temperature (90-212°F / 32-100°C) geothermal energy can be used directly for heating and cooling buildings, growing crops, drying lumber, and other industrial applications

Icograms: https://icograms.com/templates/898/district-heating

Geothermal Energy Potential: Electricity Production

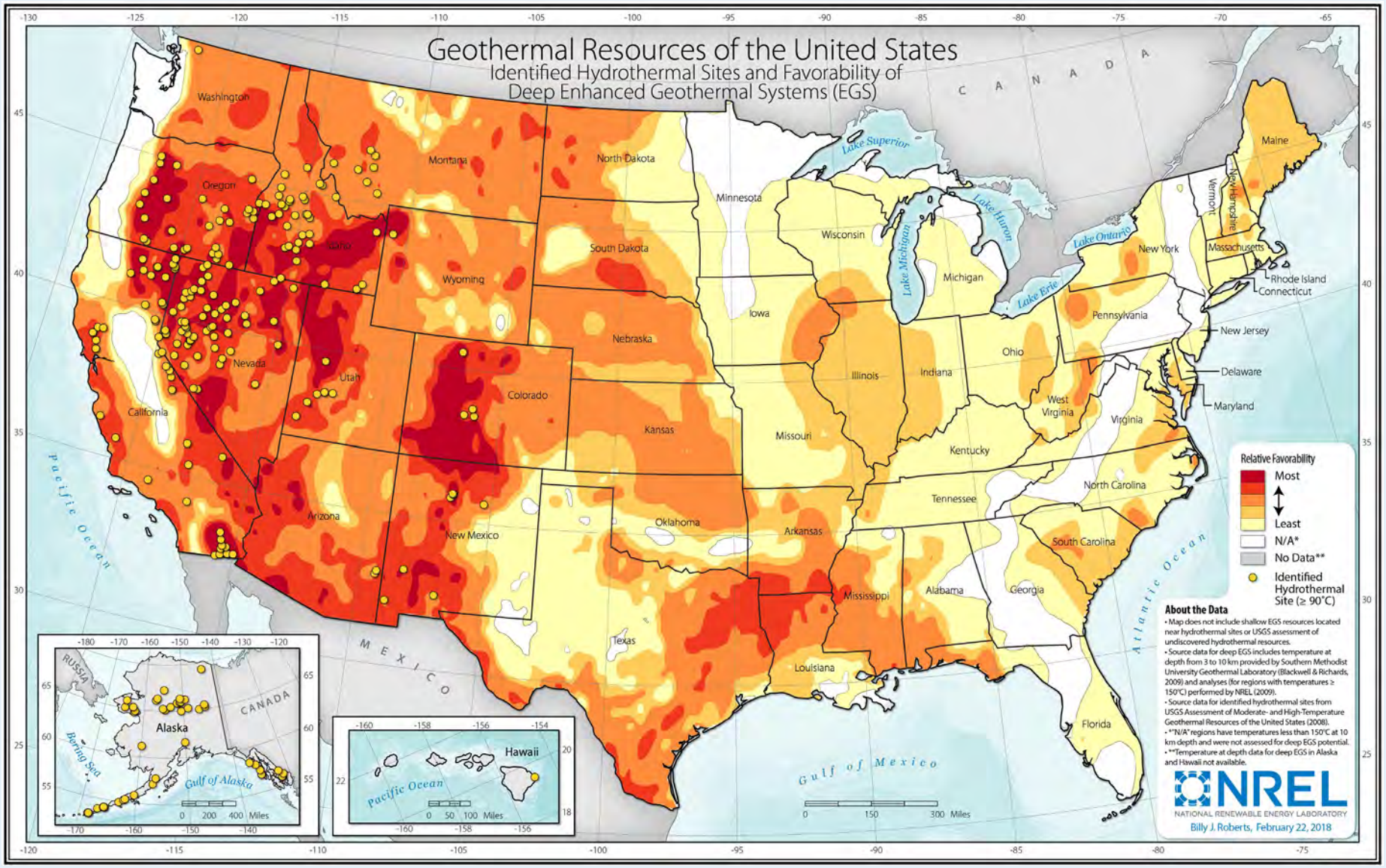
Mining Heat

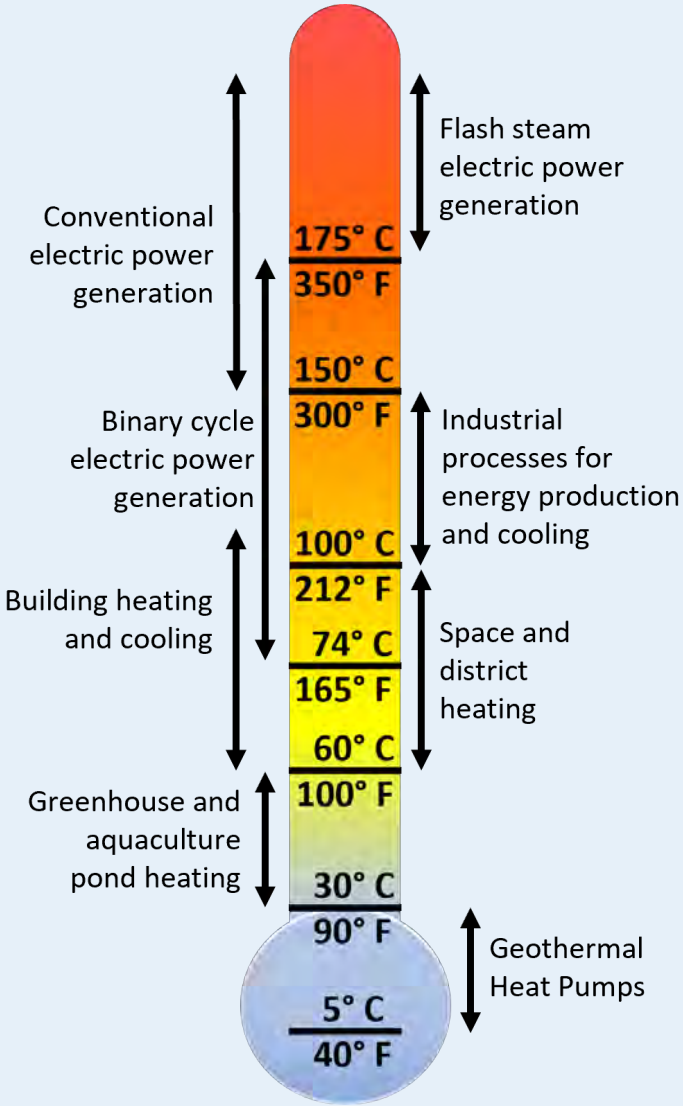


Medium temperature (165-350°F / 74-175°C) geothermal energy can be used for electricity production; high temperatures (>350°F / > 175°C) for flash steam electricity production

US Department of Energy, https://www.energy.gov/eere/geothermal/geothermal-electricity-generation

Geothermal Energy Potential: United States

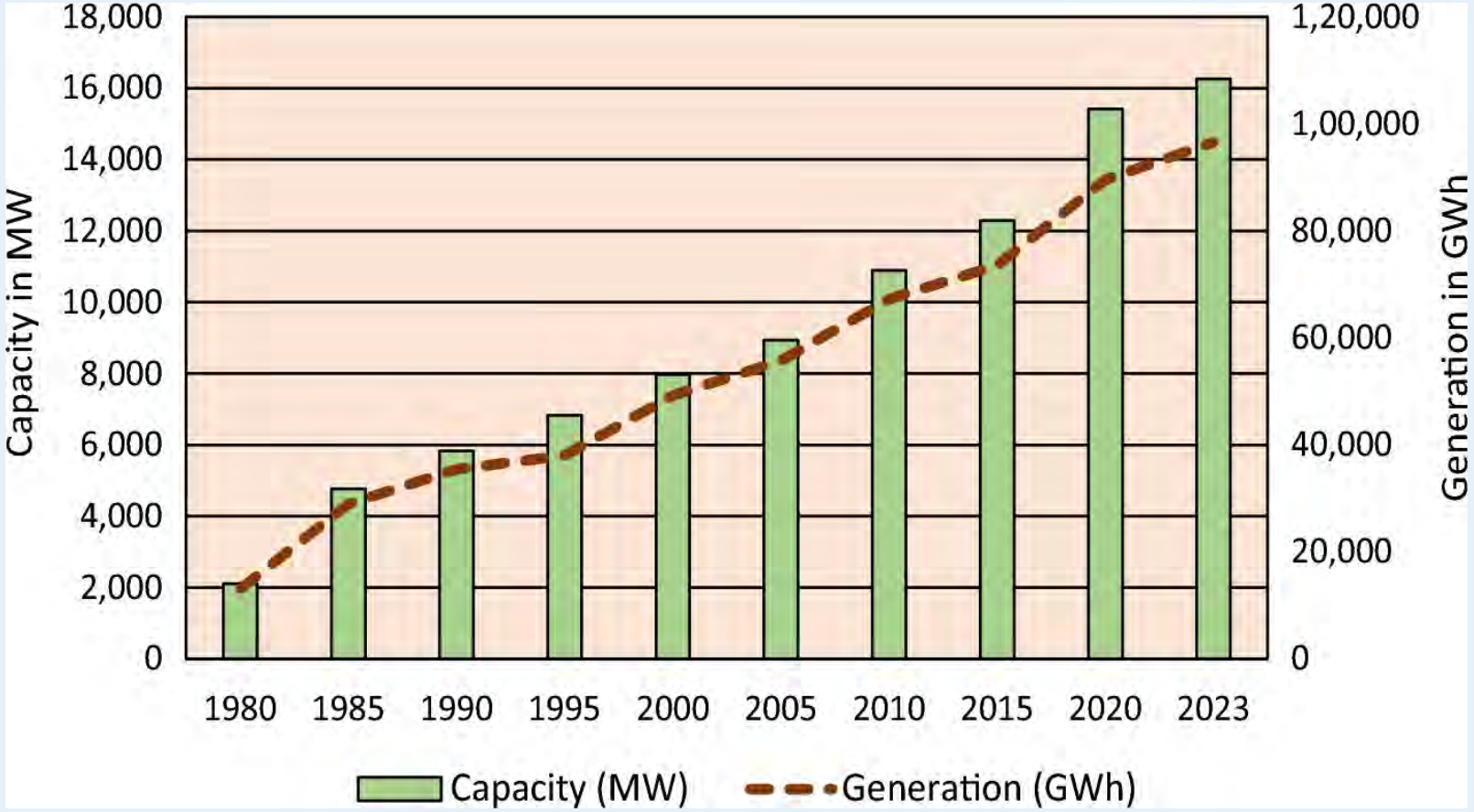




National Laboratories of the Rockies: https://www.nrel.gov/gis/geothermal

Geothermal Energy Potential: Electricity Production

- 32 countries have geothermal power plants in operation, with a combined installed capacity of 16,318 MW in 2023. This represents a 0.16% of worldwide electric installed capacity.
- Nearly 30% of worldwide geothermal installed capacity is found in the U.S. (4,876 MW), primarily western U.S.
- In 2022, electric generation from geothermal plants in the U.S. amounted to 18,702 GWh
  - 0.4% of total U.S. electricity production
  - 2% of U.S. electricity produced from renewable resources



World geothermal capacity and electric generation between 1980 and 2023. *Source: Gutiérrez-Negrín, L.C.A. Evolution of worldwide geothermal power 2020–2023. Geotherm Energy 12, 14 (2024). https://doi.org/10.1186/s40517-024-00290-w*

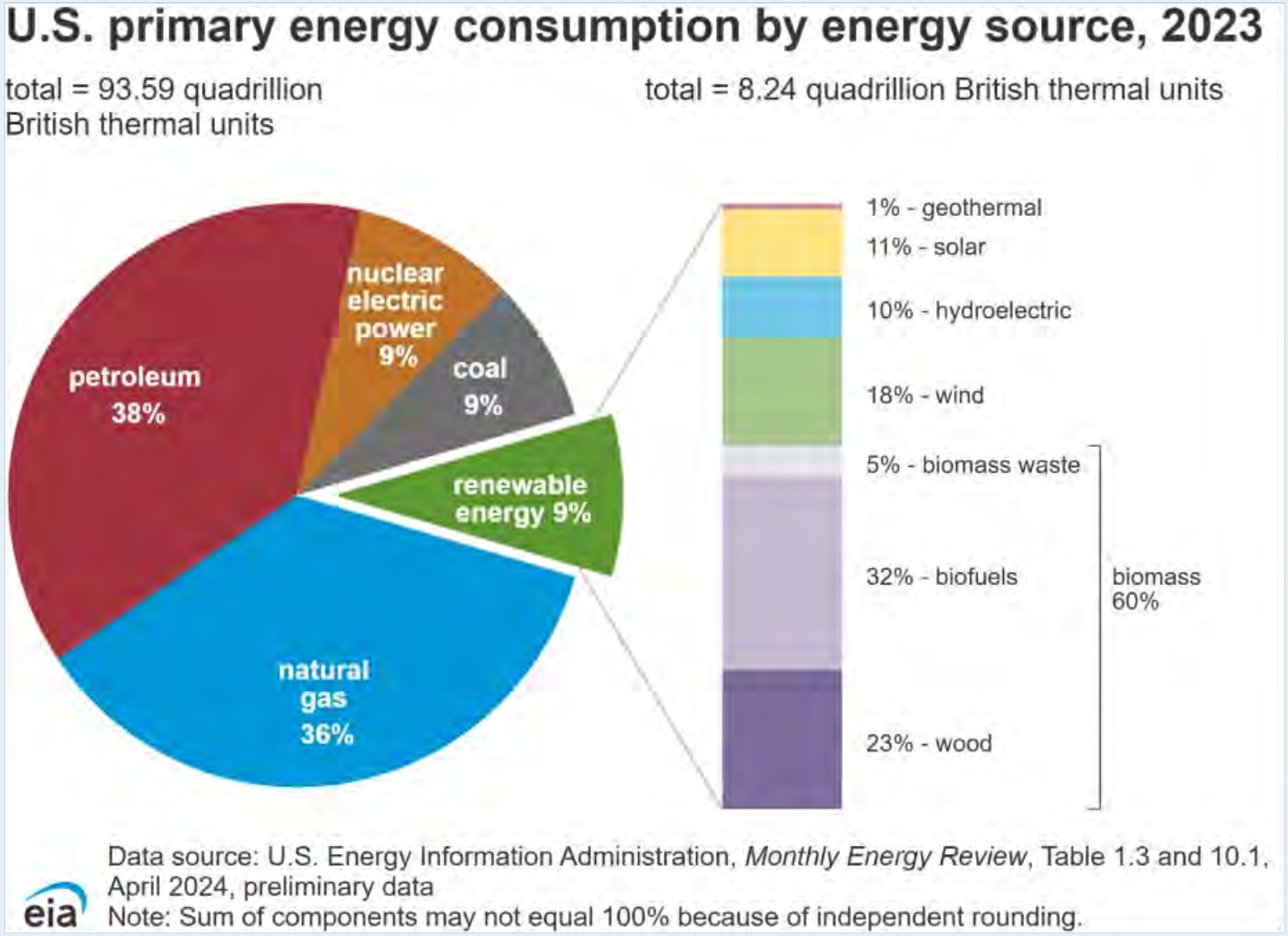
Geothermal vs Other Renewable Energy Sources

Source of U.S. electricity generation in 2024:

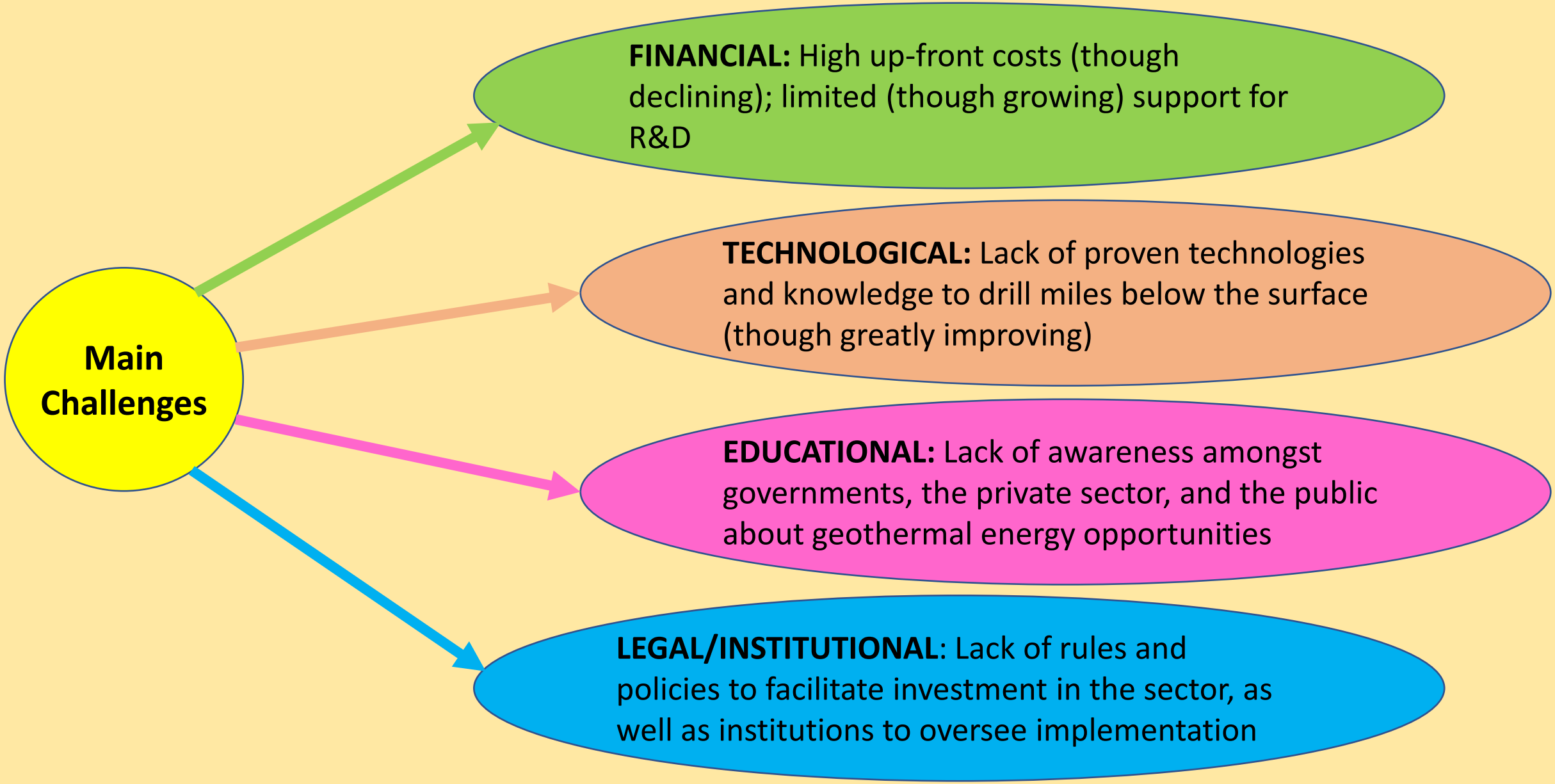
- **Wind = 10.5%**
- **Solar = 7%**
- **Geothermal = 0.35%**

U.S. Energy Info. Admin., *Electric Power Annual (with Data for 2024):*

- *Table 3.1.A. Net Generation by Energy Source: Total (All Sectors), 2014–2024,* https://www.eia.gov/electricity/annual/table.php?t=epa_03_01_a.html
- Table 3.1.B. Net Generation from Renewable Sources: Total (All Sectors), 2014–2024, https://www.eia.gov/electricity/annual/table.php?t=epa_03_01_b.html



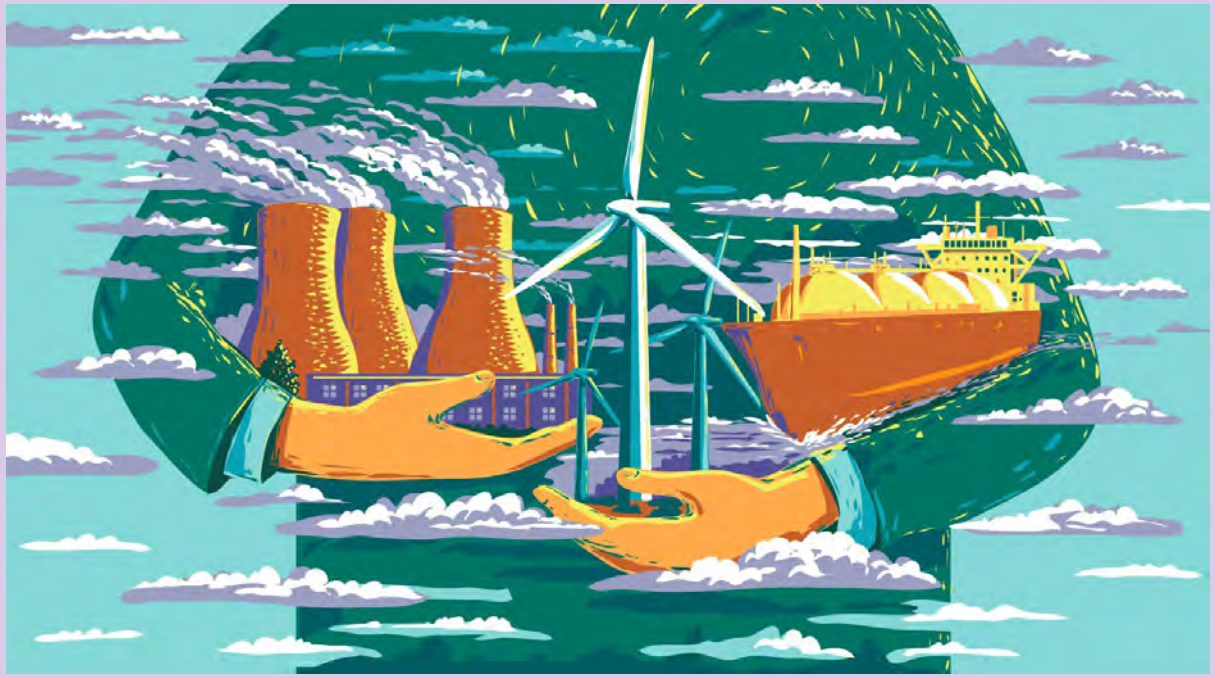
Challenges for the Geothermal Energy Industry



Geothermal Energy in a Property Context

Why Ownership?

- Property is indispensable for market systems to function
- Clear rules for ownership of property provide:
  - Owners with incentives to invest in and develop their properties
  - Responsibility and accountability for the use, management, and even non-use of the resource, as well as liability for negative externalities
  - The legal framework on which a regulatory system can be constructed
  - Investors with critical information on investment potential



Geothermal Energy in a Property Context

- Property = the condition of being owned by or belonging to some person or persons (*Oxford English Dictionary*)
- Ownership = refers to the act of possessing something such that it is subject to physical or legal control
  - Tangible = real estate, car, book
  - Intangible = patent, song lyrics
- Some “things” defy or challenge ownership
  - Air
  - Environment
  - Birds and fish
- Geothermal energy?

Geothermal Energy in a Property Context

Characterizing Geothermal Energy

- The heat force generated and stored within the Earth's interior
  - Non-physical, non-tangible resource that cannot be broken down into smaller components
  - Cannot be contained or confined
  - Fugacious
  - Has virtually no mass or weight since it is not composed of matter
  - A property or characteristic of a system or object that enables it to perform work or produce a change
- Exist as thermal energy and is not usable directly; must either be transferred into a physical medium that can contain the heat, or be converted into another, more readily useable energy form, like electrical energy
- Extraction of thermal energy (or "dumping" of "colder" thermal energy) in excess of natural replenishment can reduce reservoir temperature

So, how exactly can you "own" thermal energy?

Geothermal Energy in a Property Context

Private Property Approaches

- Ad Coelum Doctrine
- Rule of Capture

Property-Related Tort Liability

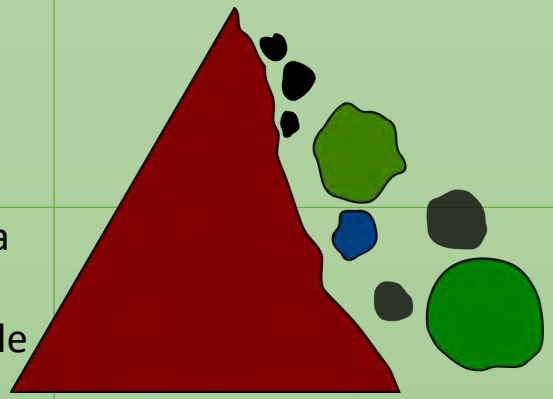
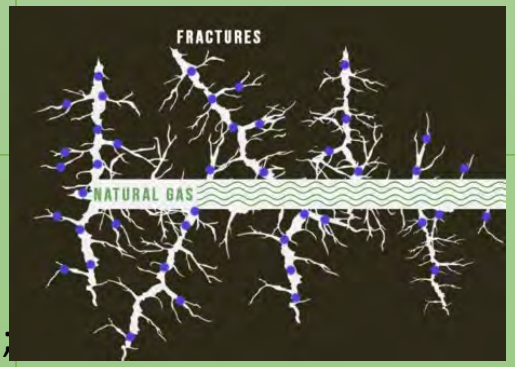
Non-Private Property Approaches

- Common Pool and Open Access
- Public Ownership

Geothermal Energy in a Property Context: Private Property

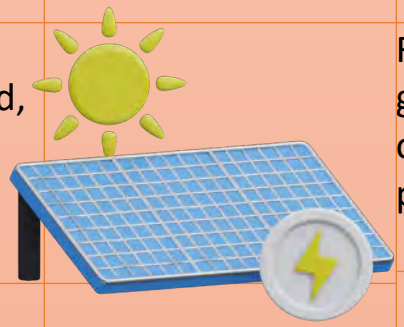
	Ad Coelum Doctrine		Rule of Capture	
Rule	Landowners have property rights extending indefinitely above and below their land (from heaven to hell)		Ownership of an unowned thing is awarded only after it is reduced to possession	
Examples	Applied to immovable things on property, like trees, coal, subsurface pore spaces; more controversial for fugacious resources		Applied to fugacious, fluidic, gaseous resources * Wild animals * Groundwater (TX) * Oil & Gas (TX)	
Notes	Whittled down in response to modern realities and scientific knowledge * Overlying air space * Fluidic/gaseous resources (e.g., groundwater, oil, gas)		Allows landowner to legally "steal" the resource (with few exceptions, e.g., malice or waste) from neighbor's property by enticing or causing it to migrate	

Geothermal Energy in a Property Context: Tort Liability

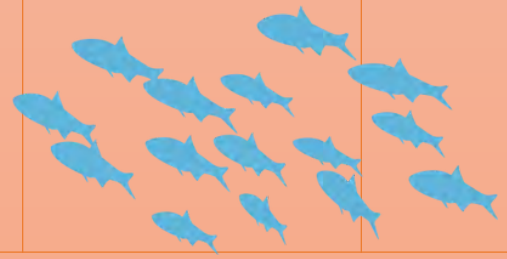
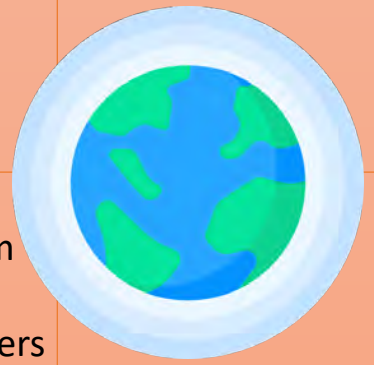
	Trespass		Nuisance	
Rule	Interference with another person's real property rights committed by entering the property without invitation		Conduct or activity occurring on one property that unreasonably interferes with the use or enjoyment of another's property (effectively a trespass without physical invasion)	
Examples	* Blasting: rocks blown onto a neighboring property due to nearby blasting is an actionable trespass * Water flooding for oil/gas development = ***not trespass in TX; is trespass in NM*** * Fracking for gas development = ***not trespass in TX; is trespass in PA***		No nuisance found: * Oil drilling is ***not an ultrahazardous activity requiring strict liability*** * Hydraulic fracturing is ***not an abnormally dangerous activity requiring strict liability***	
Notes	* Can result from activity or thing managed or controlled by the actor * Does not need actual damage; the uninvited entry is actionable harm		* Higher threshold for impact than trespass ("unreasonable and substantial") and must be either "intentional" or the result of "negligence" or a "strict liability" activity	

Geothermal Energy in a Property Context: Non-Private Property

	Common Pool	Open Access	Public Ownership
Rule	Resources typically collectively owned by or accessible to a defined community or group of individuals	Resources effectively unowned, unregulated, and accessible by any member of society	Resources owned by the government/state on behalf of or in trust for the general public
Examples	Certain forests, grazing lands, fisheries, lakes	Solar energy, oceans, atmosphere	* Natural resources subject to the "Public Trust," s.a., air, navigable water, tidal lands and coastal shores, the high seas * Resources with important economic, strategic, cultural, environmental or other values, s.a., park lands, wildlife refuges, archeological sites, marine resources, and certain wildlife and endangered species
Notes	Typically defined in terms of: * Excludability - the extent to which others can be prevented from accessing or using the resource. * Rivalrousness - the extent to which the resource is finite and users must compete for each unit. The less excludable and rivalrous, the more it is likely to be a common pool or open access resource.		Can even apply to resources on private lands, s.a., surface waters and groundwater (in most states), wetlands, endangered species

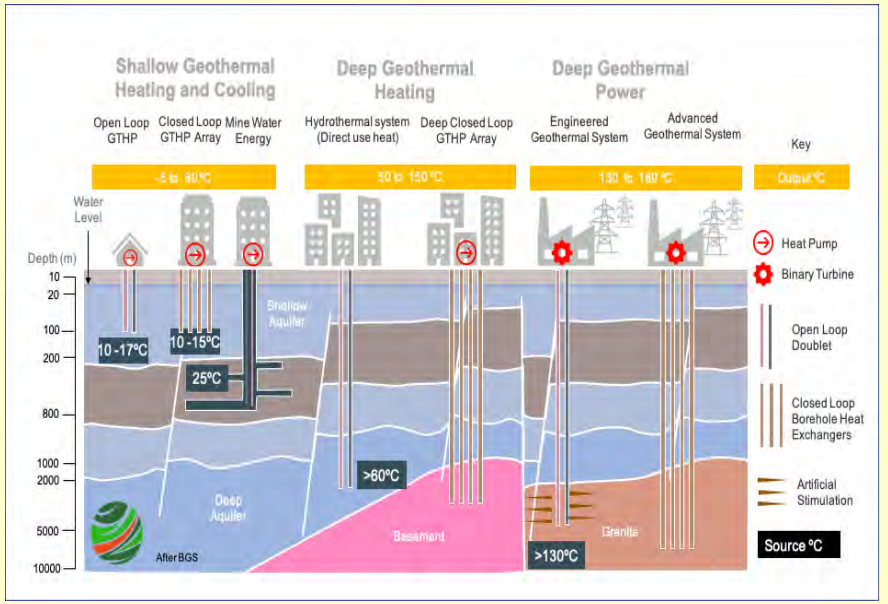



Balancing Public Stewardship and Private Enterprise

Open Access / Non-Ownership, Permits, and Rule of Capture

No private or public ownership in thermal energy while naturally in the ground; private ownership attaches upon capture



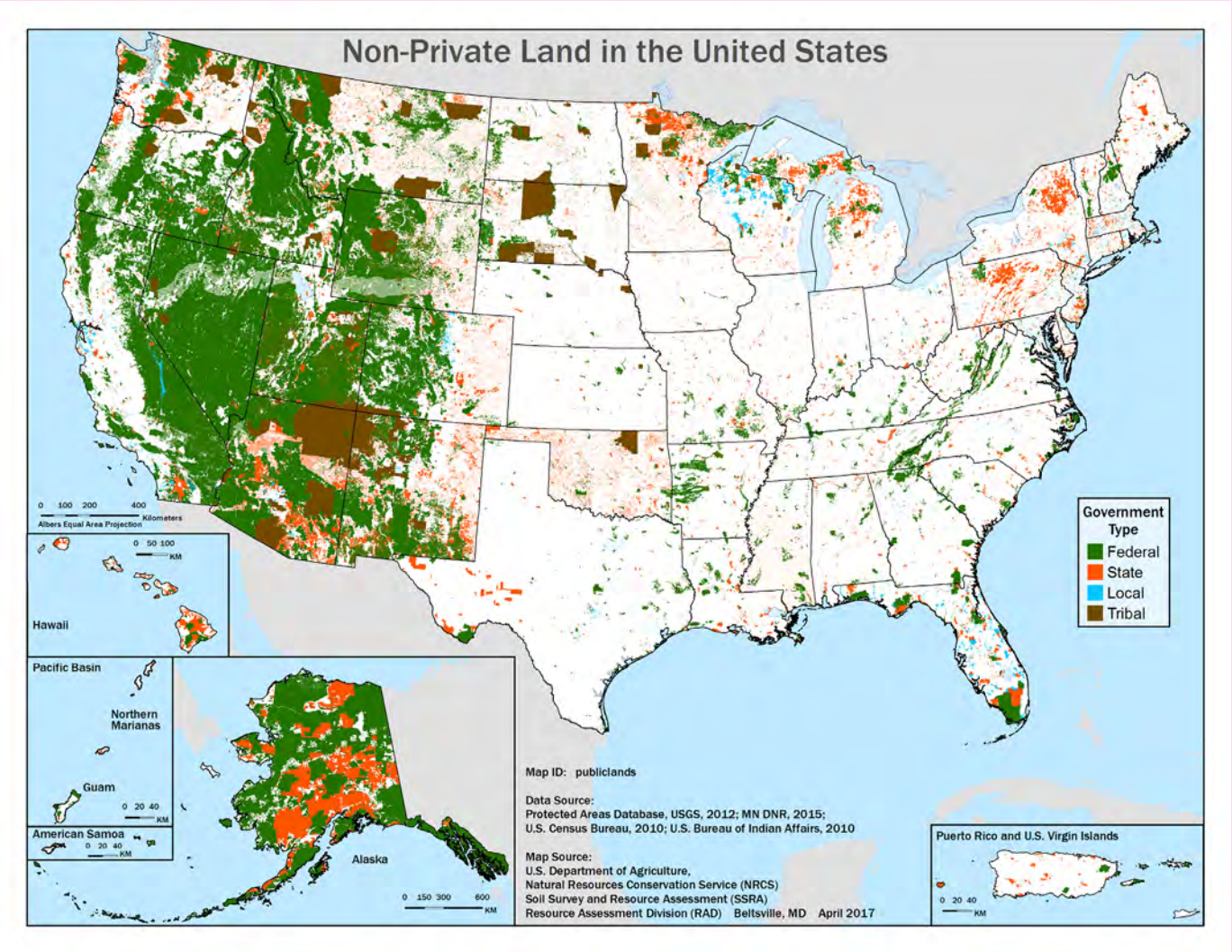
Public Ownership, Permits, and Rule of Capture

Ownership in thermal energy held while naturally in the ground by the state; private ownership attaches only upon capture

- **Private ownership in the extracted energy resources awarded only once captured and converted into a usable form (e.g., in water, as electricity, etc.)**
- **Land ownership affords exclusive access to the resource, which is transferable**
- **Subject to regulations for permitting, spacing, density, set-backs, wastage, unitization, data submissions, monitoring, reporting**

Current Ownership Laws

Federal Land
* Ownership of geothermal resources ***explicitly*** recognized in the Federal Government * Presumption that these resources are owned as a public resource, but unclear whether if owned "*in situ*" or only upon capture



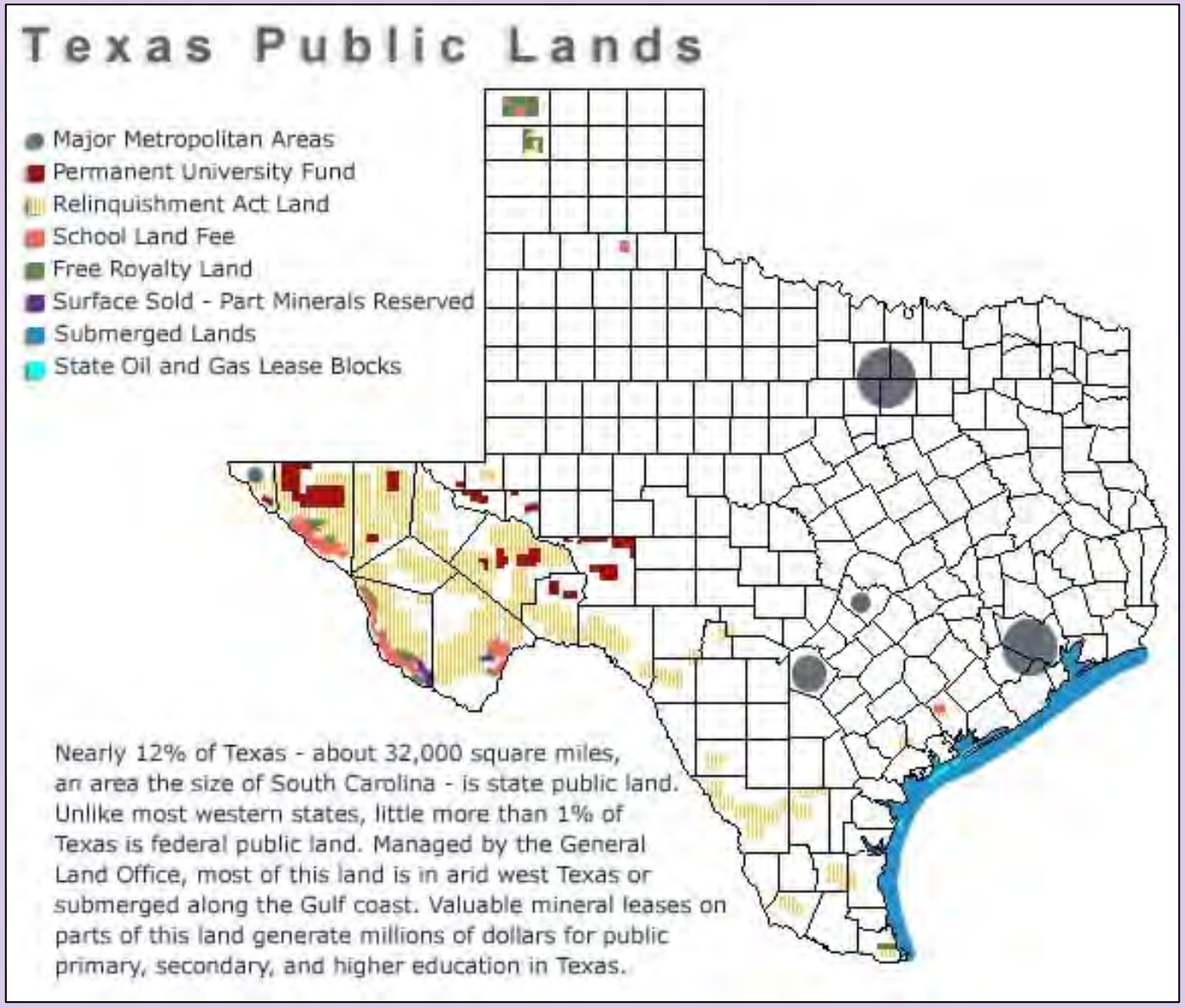
Current Ownership Laws

State-Owned Land

* Ownership of geothermal resources on state lands ***implicitly*** recognized in the state (AK, AZ, CA, CO, HI, ID, LA, MD, NE, NM, NV, OR, SC, SD, TX, UT, VA, WA, and WV)

* Ownership on state lands unclear in remaining 31 states

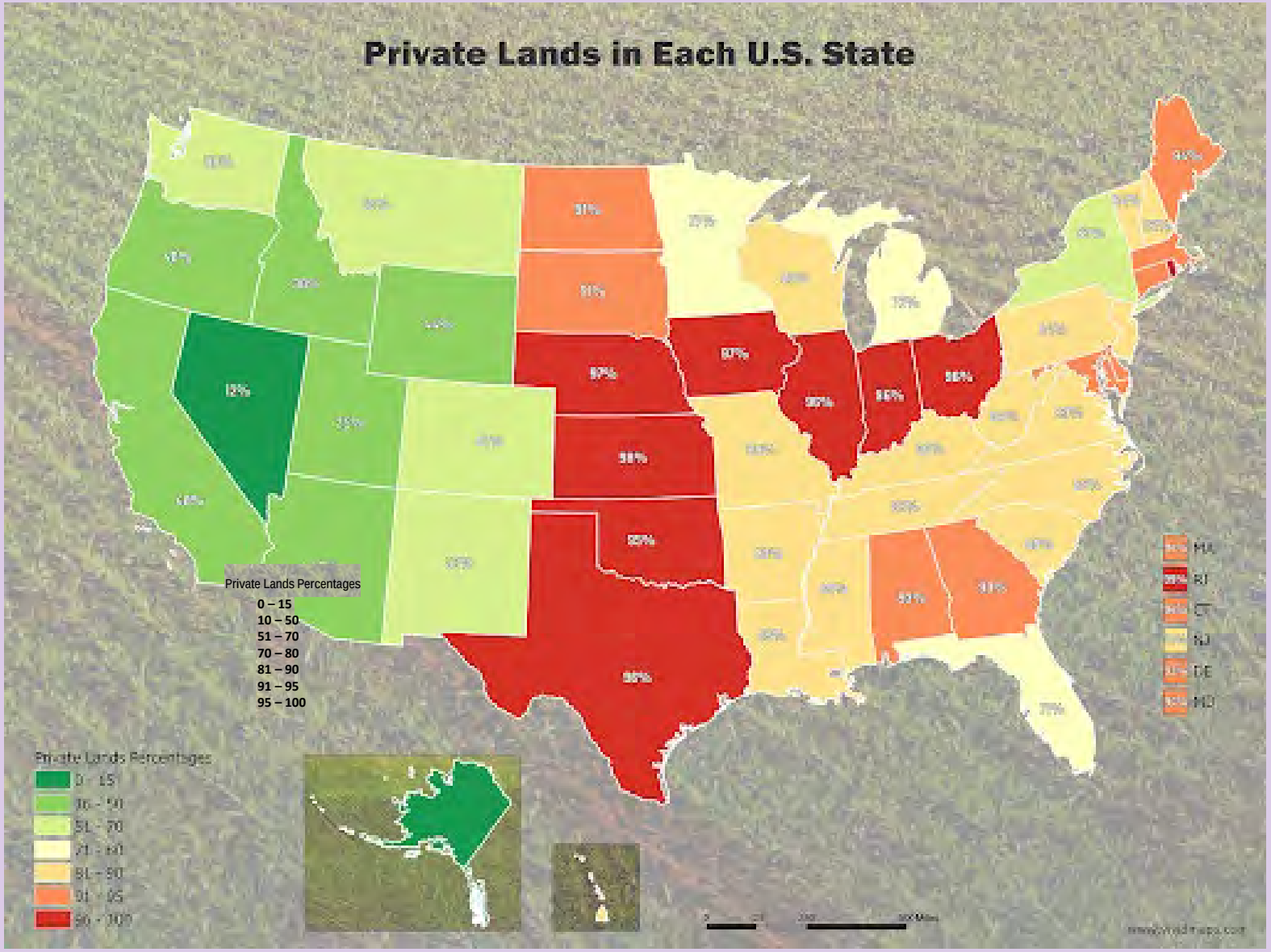
* Unclear whether owned as a public resource, privately held by the government, or if owned "*in situ*" or only upon capture.



Current Ownership Laws

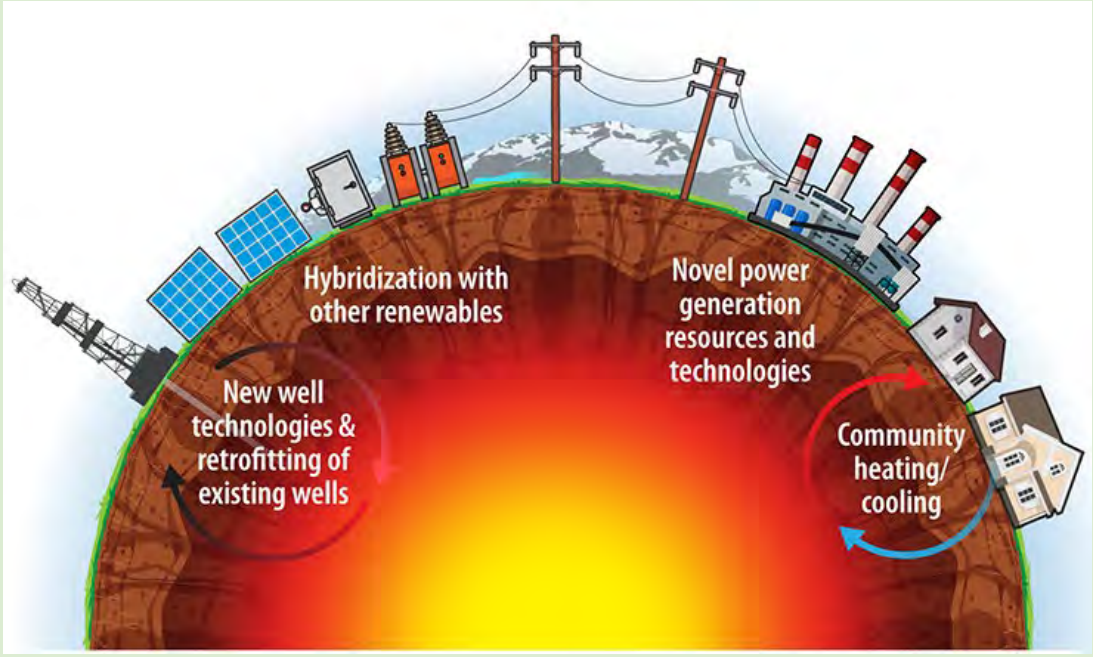
Privately Owned Land

* ***Explicitly*** recognized in the landowner (NV, OR, TX, UT, VA, WA, and WV)
* ***Implicitly*** recognized in the landowner (ID and MT)
* ***Explicitly*** recognized in the owner of the mineral estate (CA, NE, and NM)
* ***Implicitly*** recognized in the owner of the mineral estate (AL, AR, CT, DE, IL, IN, IO, KY, LA, MA, MD, NJ, NC, VT, and WI)
* ***Explicitly*** retained by the state (AK)
* Ownership related to ***groundwater*** allocation regime (CO and WY)
* **BUT**, most are unclear whether owned "*in situ*" or only upon capture.
* Remaining 20 states ???



Gabriel Eckstein, ***Who Owns the Heat? Property Rights in Geothermal Energy***, University of Illinois Law Review, Vol. 2025(2), pp. 491-553 (2025), *available at SSRN*: https://ssrn.com/abstract=5066007

Gabriel Eckstein, ***Owning Geothermal Energy***, Michigan Journal of Environmental and Administrative Law (*forthcoming 2026*)



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