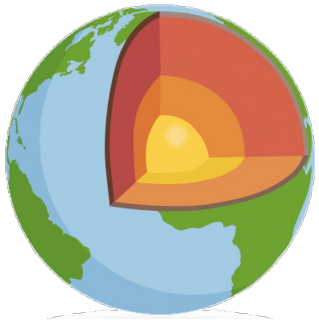
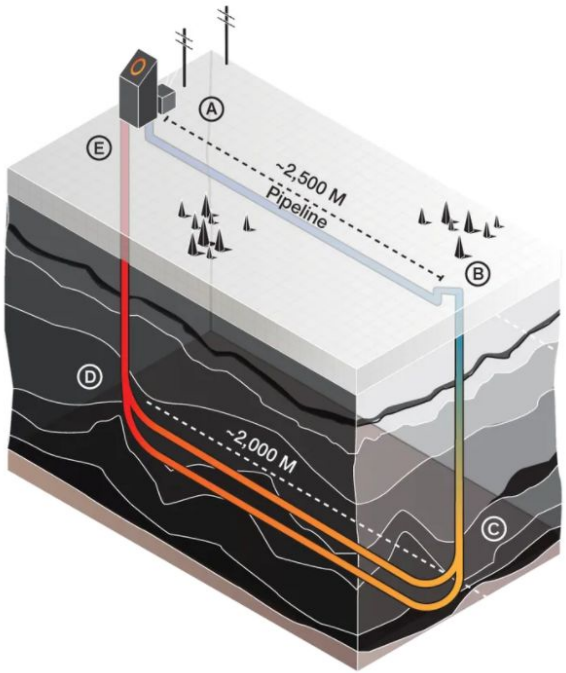
Developing New Mexico's Geothermal Heat and Electricity





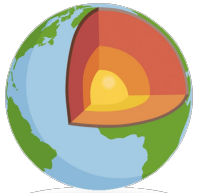
Nov 7, 2023 at WNR

Senator Gerald Ortiz y Pino

Tom Solomon

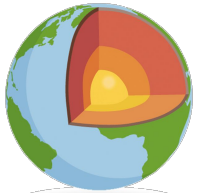
Shari Kelley, PhD

EAVOR 12min geothermal explainer **video**



Agenda: Developing NM Geothermal

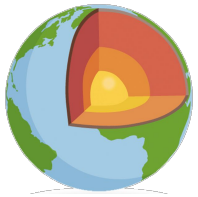
- Geothermal overview & goal
- Geothermal development bill
- Development opportunities: Phase 1 & 2
- Updates for Fall 2023
- Questions and answers



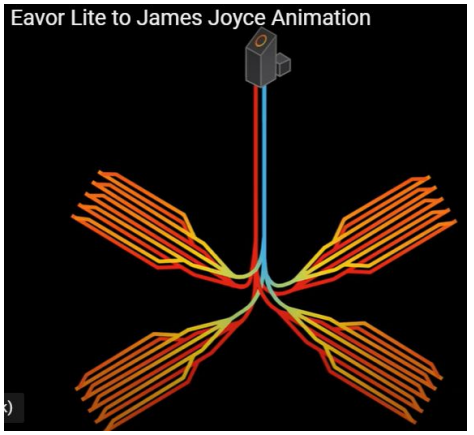
Geothermal Working Group

Meeting monthly since Feb 2022

- Senator Gerald Ortiz y Pino
- Senate Pro Tem Mimi Stewart
- Tom Solomon, facilitator
- Dr. Shari Kelley, NM Tech
- Dr. Olga Lavrova, NMSU
- Dr. Patricia Sullivan, NMSU
- Zach Millimet (Sen. Martin Heinrich DC office)



Why Geothermal Heat Energy & Electricity?

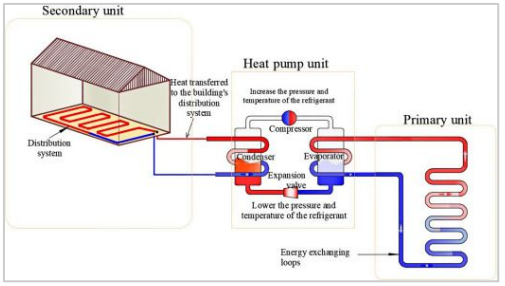


- Clean, zero emissions source of heat & electricity
- A world-class 24x7 power source in New Mexico
- May provide “last 10%” of clean energy transition
- Sustainable economic development for NM
- Re-use skills & drilling rigs from the oil industry.
  - A ‘just transition’ for workers - drill for heat

Geothermal Goal

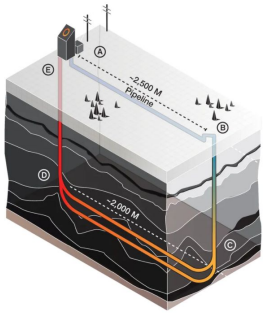
^Masson Farms in Dona Ana county

Our goal - Pass a funded geothermal energy development bill in **2024** to support the two-phase development of geothermal energy in New Mexico:

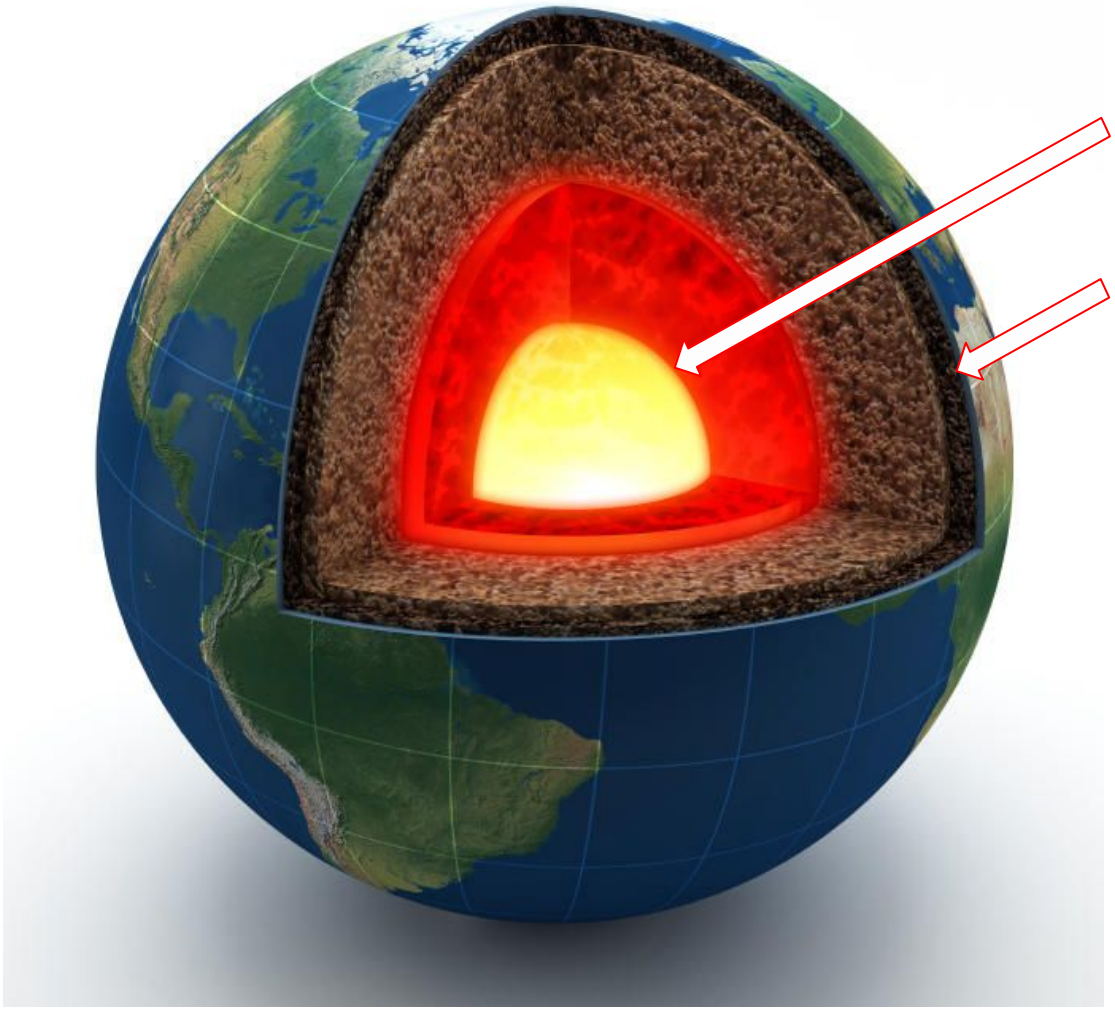


Phase 1) In the **2020**'s expand known existing geothermal resources: in green houses, heat pumps for buildings, hot springs & spas, for clean electricity (Lightning Dock), etc.

Phase 2) promote longer term development of advanced geothermal electricity to provide the final 10% of clean NM grid electricity through the **2030**'s: 1 to 3 GW.



Geothermal Energy: Using Earth's Heat



The temperature in the **inner core** is ~5,200°C or **9,392°F**

Five miles underground it can be 204°C or **400°F** *

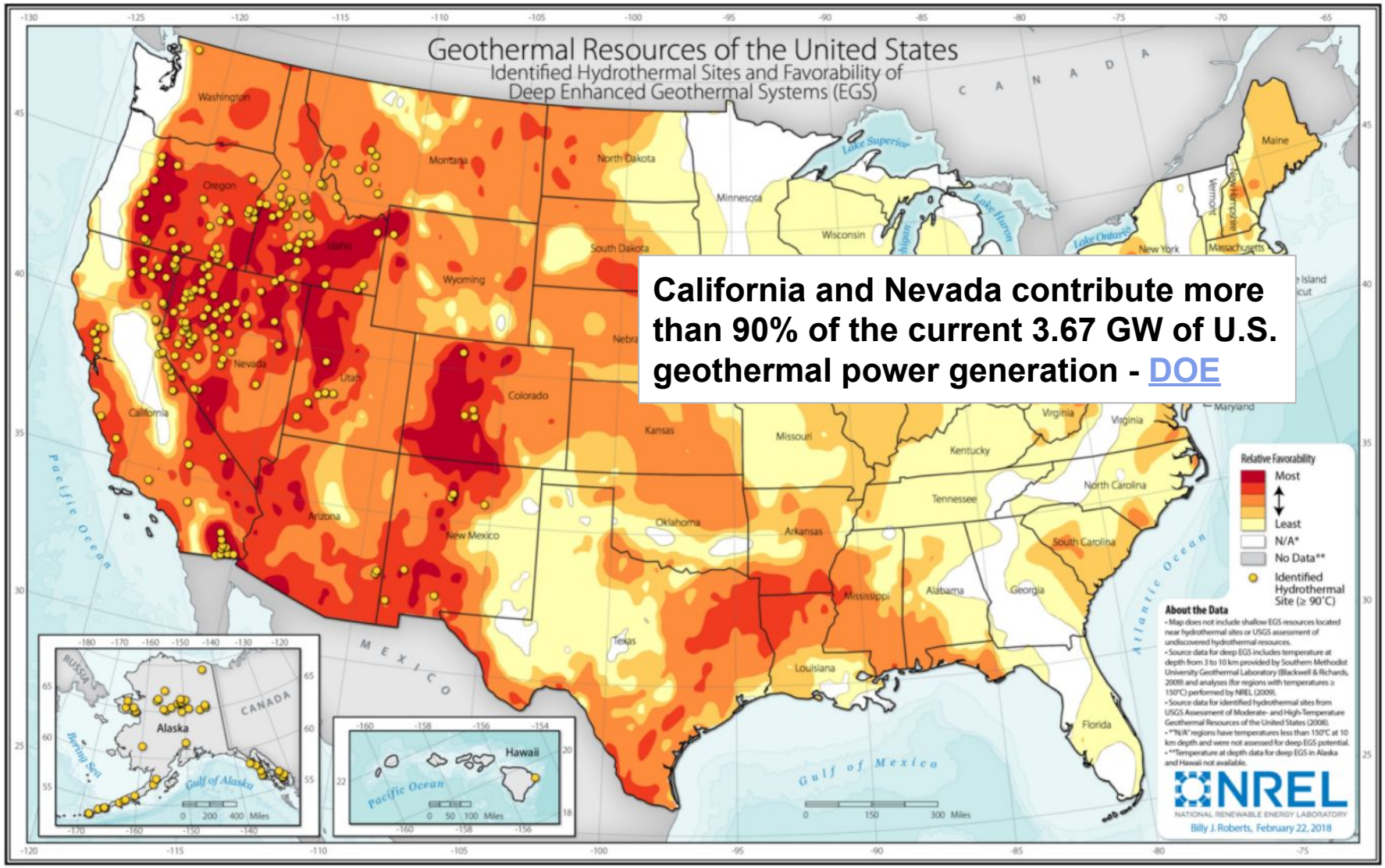
Temps can be higher at shallower depths where the crust is thinner.

** Well above boiling temp of water, ie **212°F** at sea level.*

https://earthscience.stackexchange.com/questions/240/is-the-earths-hot-inner-core-necessary-for-life
https://education.nationalgeographic.org/resource/core

NM Ranks #6 in Geothermal Resources

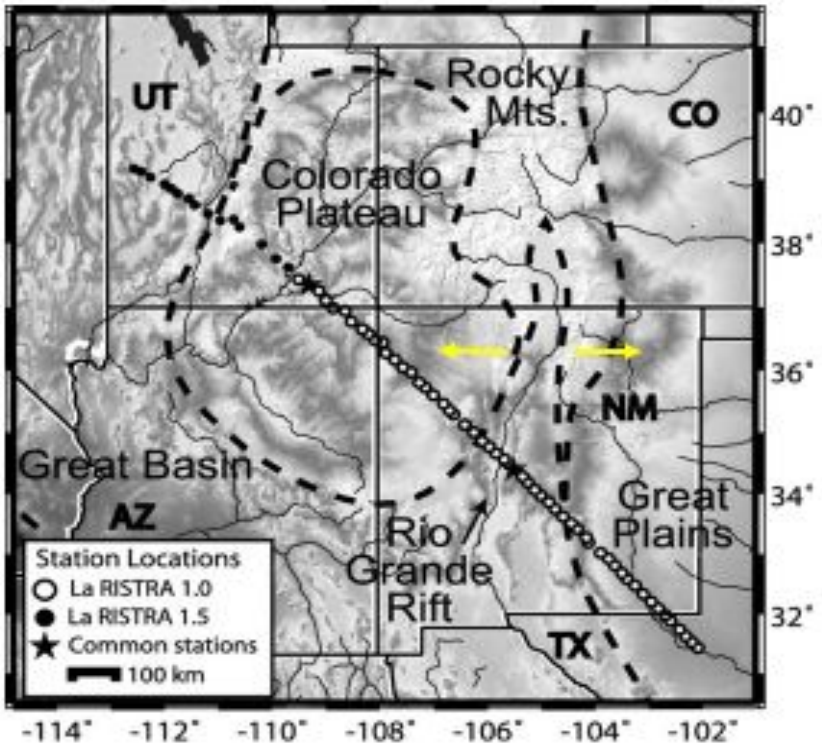
NREL map at depths of **3km-10km** (~10k to 33k ft)



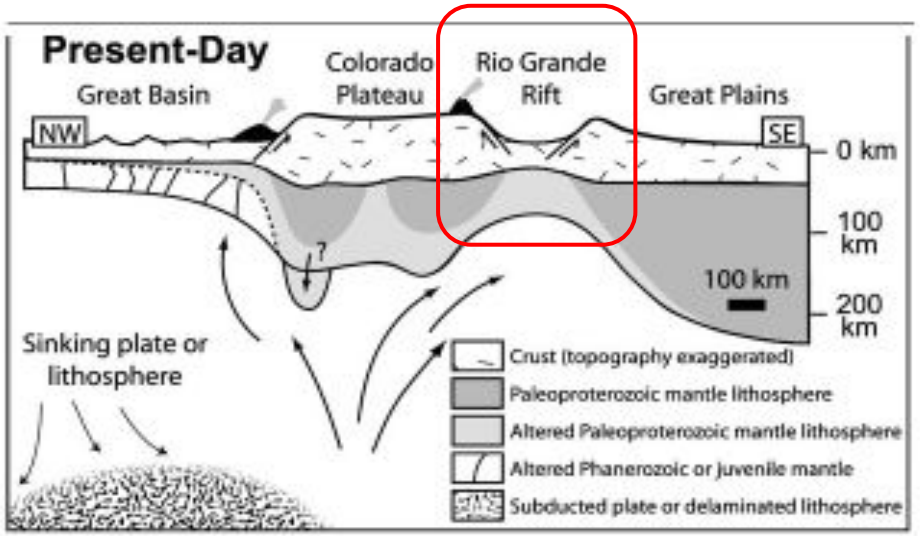
https://www.nrel.gov/gis/geothermal.html

Rio Grande rift heat source

LA RISTRA seismic experiment



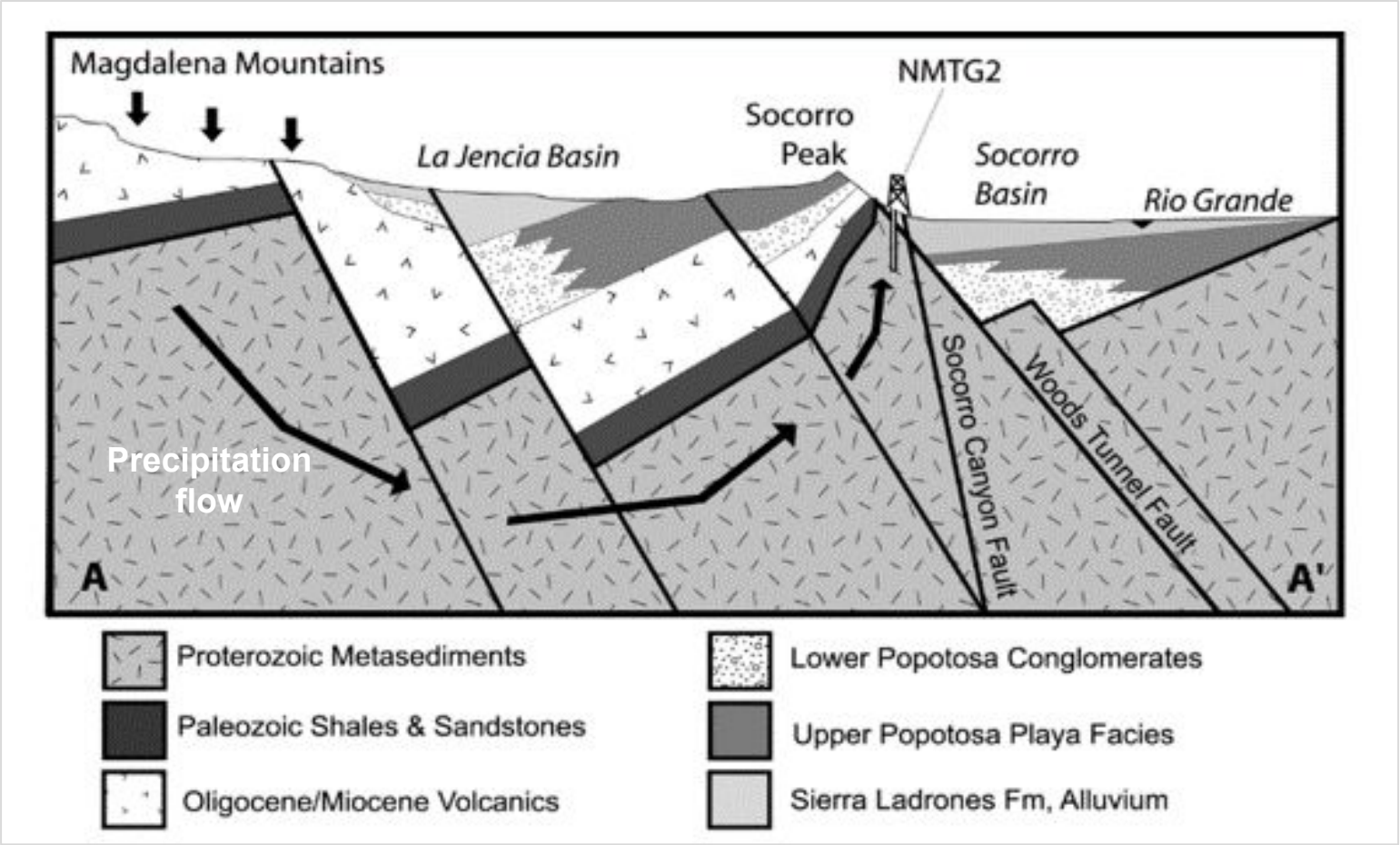
Interpreted cross sectional view



Wilson et al., 2008

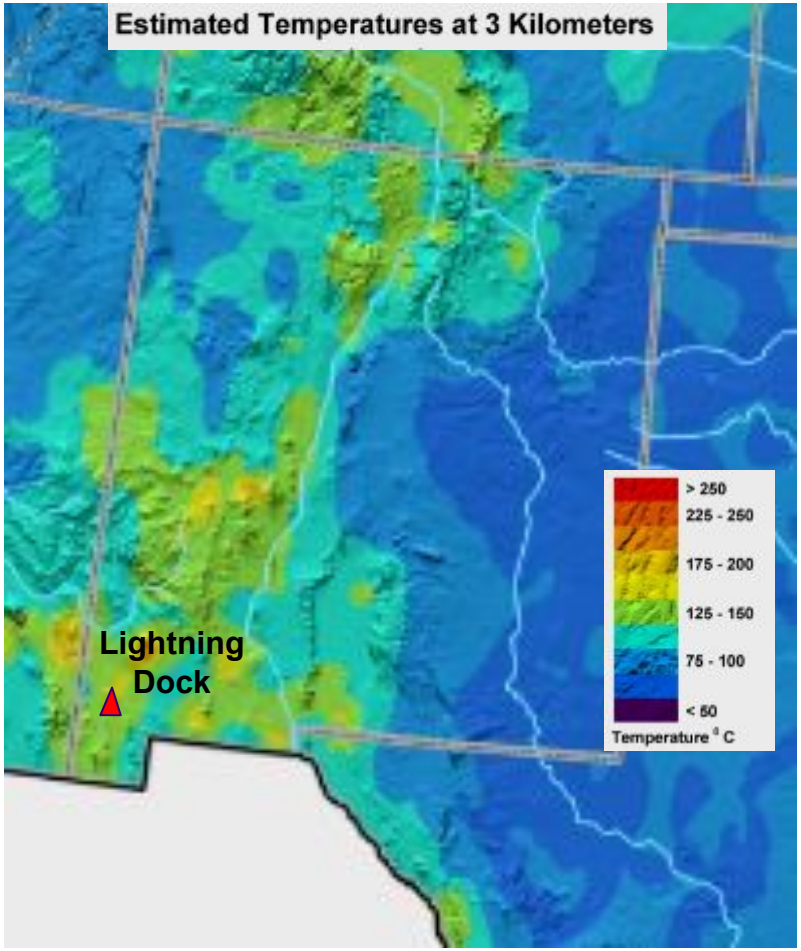
- Extension associated with the Rio Grande rift causes thinning of the crust, upwelling of hot mantle, and elevation of subsurface temperatures along the Rio Grande corridor.
- Thinning also occurs in the Basin and Range of SW NM.

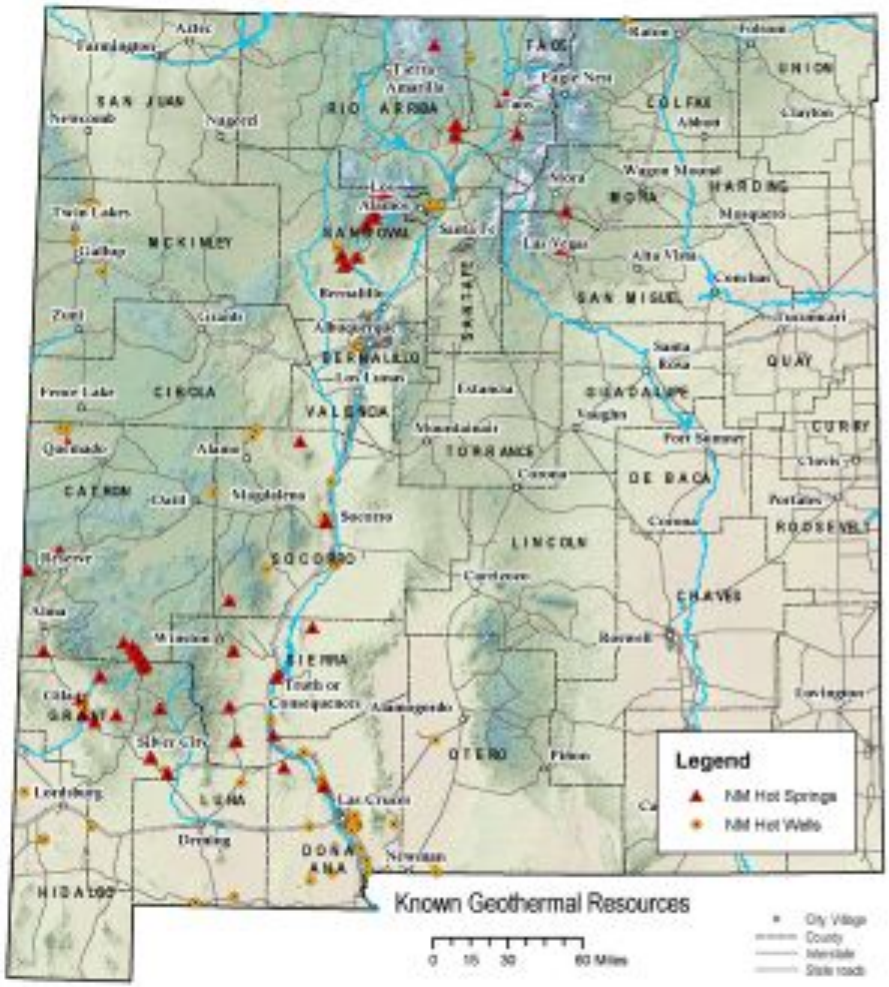
Gravity-driven system, Socorro



- Precipitation percolates into the subsurface, where it is heated by elevated temperatures associated with the Rio Grande rift extension.
- Heated groundwater moves back up to the surface along rift-related faults.

NM Regions of Known or Potential Geothermal Resource (USGS)



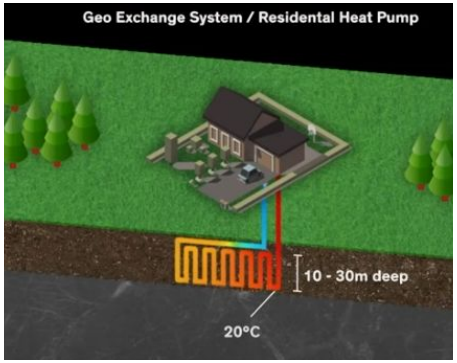


Both the high temperatures (>125°C) estimated at 3 km and the location of known resources are generally associated with extension in the the Rio Grande rift/Basin and Range.

https://my.usgs.gov/eerma/data/index/4f4e483ce4b07f02db4f1bb8
https://my.usgs.gov/eerma/data/index/4f4e4a63e4b07f02db637aab

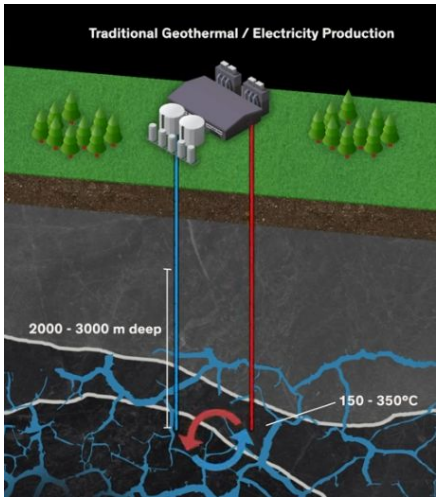
Types of Geothermal by Depth

Geothermal today, phase 1:



- **Ground source heat pumps**
  HVAC for buildings: 5 feet to 300 feet deep.

- **Hot Springs & direct use**.
  Depths to ~1000 ft.



- **Traditional geothermal electricity** from a hot water aquifer: > 6000 ft. (Lightning Dock)

Geothermal future, phase 2:

- **Ph2 - Advanced geothermal electricity:**
  closed loop in deep hot rock: > 15,000 ft.

Eavor video https://www.youtube.com/watch?v=PtQmGPmyLA0

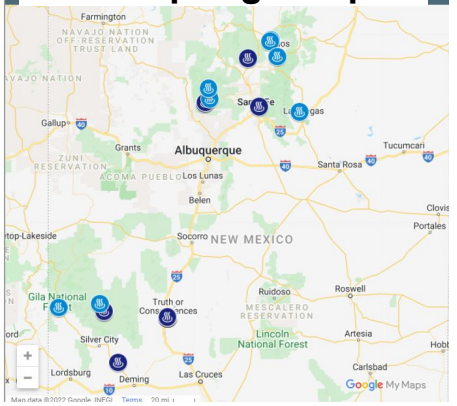
Geothermal in New Mexico Today

- **Masson Farms**: 2nd largest GT greenhouse in US
  - 20 acre GT greenhouse complex in Radium Springs
  - Geothermal saves 93% on heating bill. Employs ~200

- **Lightning Dock** electric plant near Lordsburg
  - 15 MW geothermal electric generation for PNM

- **29 hot springs** in New Mexico
  - Ex: San Antonio Hot Springs, Jemez Springs, Gila Hot Springs, *Black Rock, Faywood,* Ojo Caliente, etc.

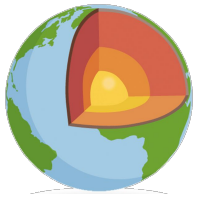
Hot springs map



- **AmeriCulture aquaculture** farm near Lordsburg
  - Tilapia fingerlings aquaculture farm w/ GT heating from a 400 ft well

AMERICULTURE

- **Ground source heat pumps** for buildings
  - Several known school facilities in APS and RRPS & the Abq Simms bldg



Geothermal Development Bills in 2023

Sen. Ortiz y Pino & Rep. Roybal Caballero

HB365, "**Geothermal Center and Fund"**

- Created the **$10M "geothermal projects development fund"** and the **$15M "geothermal projects revolving loan fund"** (appropriations were struck).
- Provided **$600k** to **expand geothermal (GT) responsibilities at the Energy, Minerals and Natural Resources Department** (EMNRD) to: 1) administer* the geothermal grant & loan funds, 2) apply for **federal geothermal grants** and 3) assist GT applicants in using available state **economic development incentive** programs.
- Created a **Geothermal Research Center of Excellence** at NM Tech (**$500k****).

SB173, **Geothermal Energy Generation Tax Credits**

- Create a geothermal electricity **production tax credit** of **$0.015 per kWh** for geothermal electricity generation facilities prior to Jan 1, 2028 with an aggregate **annual cap of $5M** applied to personal and corporate income taxes.
- Create a **gross receipts tax deduction** for geothermal electricity generation facility **construction costs** prior to Jan 1, 2028.

These bills passed both chambers with bipartisan support, then vetoed. Re-file in 2024.

*ECMD, the Energy Conservation and Management Division in EMNRD has direct geothermal responsibility

**The NMT C of E got a one-time appropriation of $400k in HB0002FC1 separate from the HB365 pocket veto.

Over $500M in GT Federal Funds

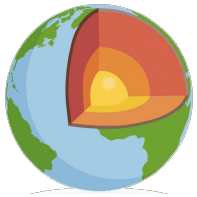
Zach Millimet, Sen. Heinrich's office

Some require state matching funds.

- **I**nfrastructure **I**nvestment and **J**obs **A**ct:
  - **$500M** for "Clean Energy Demonstrations on Current & Former **Mine Land**". Up to five projects (incl **geothermal**). Through 2026.
  - **$84M** for **enhanced geothermal** energy; 1st round closed June 16, 2023. A 2nd round is likely, tbd.
  - EPA BROWNFIELD ASSESSMENT GRANTS (COMMUNITY-WIDE ASSESSMENT GRANTS FOR STATES AND TRIBES): due 11/13/2023; up to $2M to address contaminated sites and add renewable energy.
- **$1.4** million of NSF funding for Centers for Research and Innovation in Science, the Environment and Society (CRISES).
  - Geothermal Technologies Office - funding opportunities

➡ Leveraging federal funding will require **added resources in EMNRD**

IRA funding opportunities https://www.whitehouse.gov/wp-content/uploads/2022/12/Inflation-Reduction-Act-Guidebook.pdf



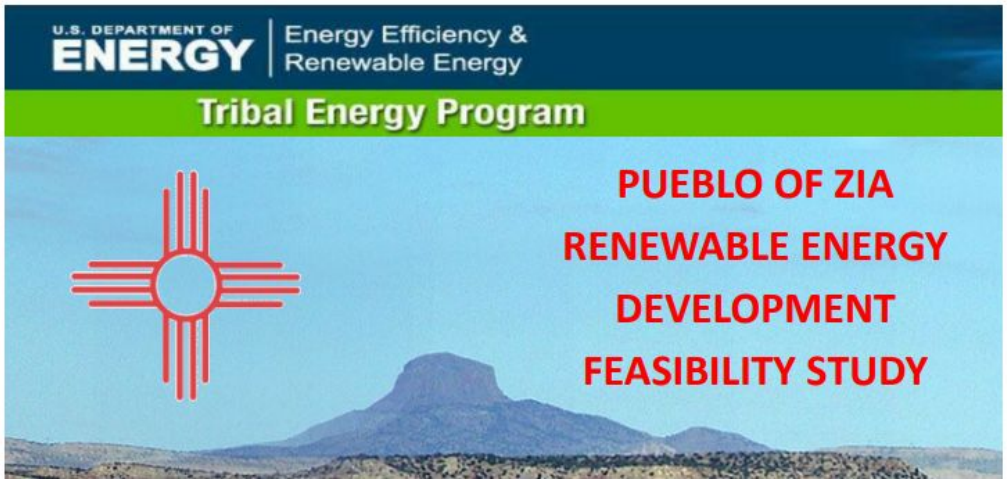
Some GT Development Opportunities

For phase 1

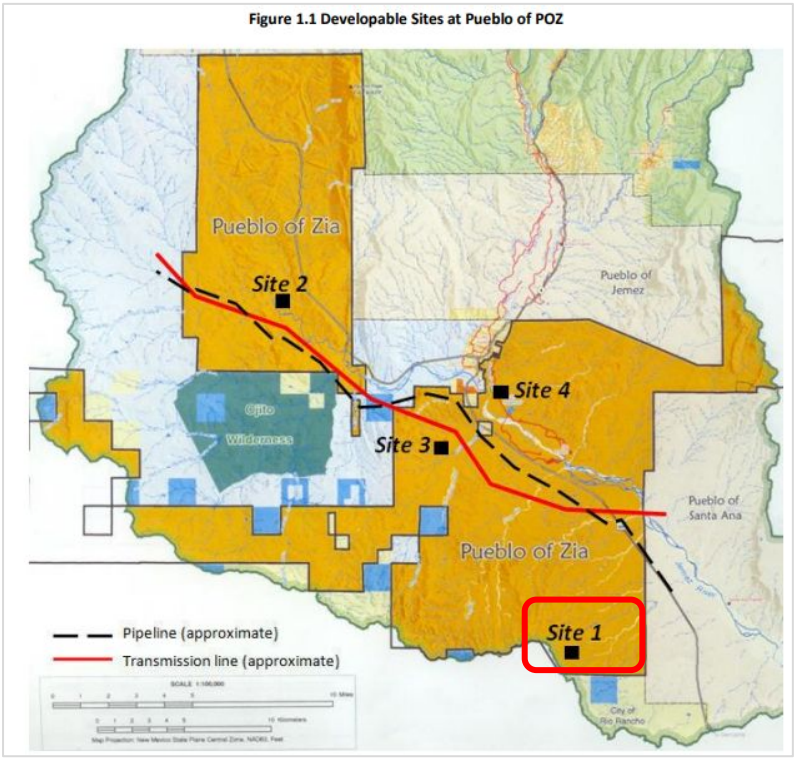
- **Zia Pueblo** DOE study 2012-2013
- **Mesa del Sol** integrated cascading community GT development
- Revive 1980's **NMSU geothermal projects**

- **NM Tech** campus district heat proposal of 2010
- **Expand Lightning Dock** geothermal electric plant
- **'Well of opportunity' on Navajo land:** a pine seedling greenhouse
- Low grade heat (129°F-180°F) for **drying chile, onions**, etc
- Revisit 1980's **Jemez Springs** attempt to develop hydrothermal

Zia Pueblo 2012-13 Geothermal Study



About 20 miles north of Albuquerque



The Pueblo of Zia (also referred to as "Zia Pueblo") conducted a comprehensive feasibility study for best-use application(s) for development of renewable energy resources on its tribally held TRUST lands (i.e., Trust Lands of Zia Indian Reservation). The feasibility study is essential for determining the technical and economic viability of a future renewable project(s) on Zia tribal lands, including the potential economic and environmental benefits for the Tribe.

Geothermal Energy Potential: **Site 1 presents the best potential geothermal site** from a strictly geologic point of analysis. This site will require the highest up front drilling cost, and delivers the best economics at a levelized cost of $79.90/MWH. Site 3 is the second best site with a levelized cost of $106.20/MWH.

https://www.energy.gov/indianenergy/pueblo-zia-2012-project

Mesa del Sol Geothermal - Jim Witcher

***Concept** demonstrating **four cascading benefits** of geothermal development.*

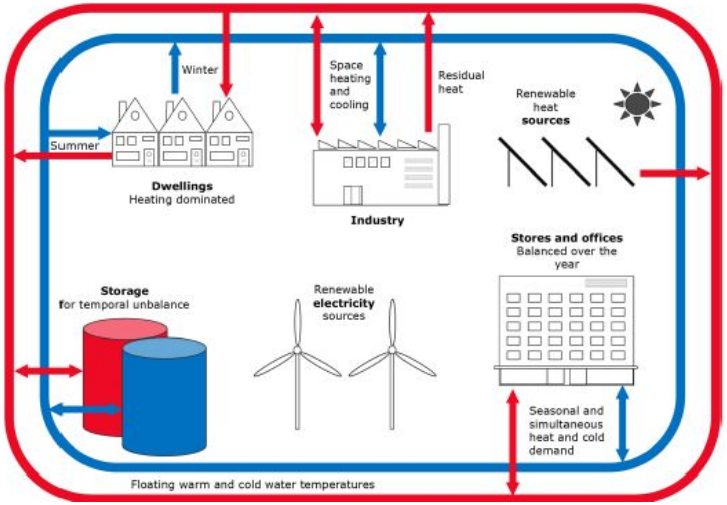
Mesa del Sol is a development south of the Albuquerque Airport

- **Clean Electricity Generation** (rough estimates)
  - 4-5MW clean electricity generation from a **13k ft well** w/300F GT water from the "Santa Rosa sandstone" formation. Need ~1000 gal/min at **300F** for a 5MW plant. Drilling costs $6-8M per well from site prep to completion over 1-2 months with a very large drilling rig. Need two wells, one for production, one for re-injection, costing $12-16M.
  - Add $3M per MW, ie $15M to build a 5MW plant. Say $30M total up front investment.
  - Might site 2-3 of these plants depending on available geothermal water flow, tbd.

- **Geothermal district heat for Mesa del Sol** like Reykjavik
  - Use outflow water from the heat exchanger before re-injection, to heat homes and businesses (eg Netflix).

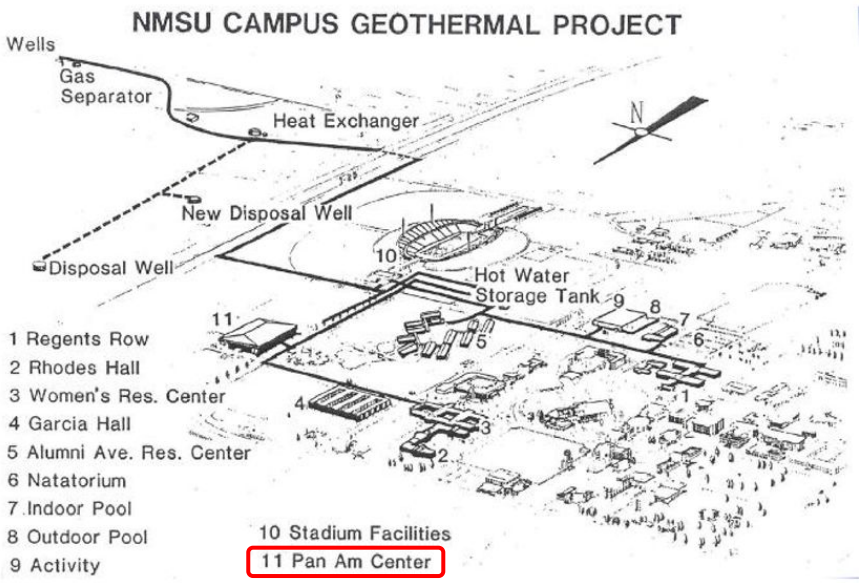
- **Industrial processes using low grade heat**
  - For greenhouses
  - Ideas include drying chilis, onions. pistachios, adobe making, Ag products need 54C-82C (129F to 180F).

- **Hot Springs/Spa tourism using outflow water**



NMSU Geothermal Project

(1979 to 2015)



- Between 1973 and 1979, NMSU experienced a >400% increase in the cost of natural gas. (somewhat similar to recent raising costs for energy worldwide).
- **An appropriation from the New Mexico Legislature provided funds for the design and construction of the NMSU Campus Geothermal Project** [1]
- NMSU Geothermal Projects provided domestic **hot water** and **space heat to dorms, athletic facilities and academic buildings.**
- In 1994, the Geothermal **Aquaculture** Facility (GAF) was built.
- **By 2015 all wells were decommissioned.**

Well	Depth ft	BHT °F	Year Completed	Casing in.	Depths ft	Diameter in.	Depths ft	Remarks
PG-1	860	145	1979	10 ID 10 ID screen	0-750	17	0-860	Produces 142°F T = 6,500 gpd/ft
PG-2	507	122	1979	6	507	9 7/8	507	Produces 18 gpm at 118°F from 451 to 171 ft depth; well currently not in use.
PG-3	870	150.4	1980	18 ID 10 ID 10 ID screen	0-60 0-750 750-860	26 18 18	0-60 26-750 750-860	Produces 146°F T = 40,000 gpd/ft Well currently not in use.
PG-4	1,015	-150	1986	14 8 5/8 8 5/8 screen 5 9/16	0-684 658-744 744-971 972-1,015	17 ½ 12 1/4 12 1/4 7 7/8	0-684 684-733 733-960 982-1,015	Produces 146°F Specific capacity 100 gpm/ft
GD-2	464	-110	1980	8 5/8 cement 8 5/8 Cement plug	0-348 348-464 464-486	14 3/4 14 3/4 14 3/4	0-348 348-464 464-486	Injection well on NMSU Golf Course Slotted screen at 370-380 ft; 390-464 ft T = 9,000 gpd/ft

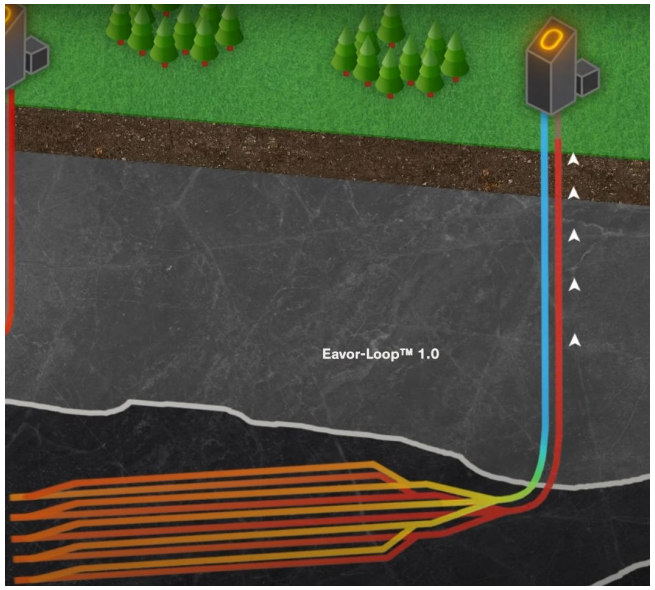
[1] Cunniff, et al., 1983

Phase 2: Adv. Geothermal Electricity

Geothermal future in phase 2:

- **Advanced geothermal (AGT)** electricity, closed loop in deep hot rock: >15,000 ft.
- Last 10% of clean energy transition
- Build **1-3 GW** of advanced geothermal electricity into 2030's
- **Need to solve two drilling tech problems**: drill bits to survive higher temps & drill through harder rocks.

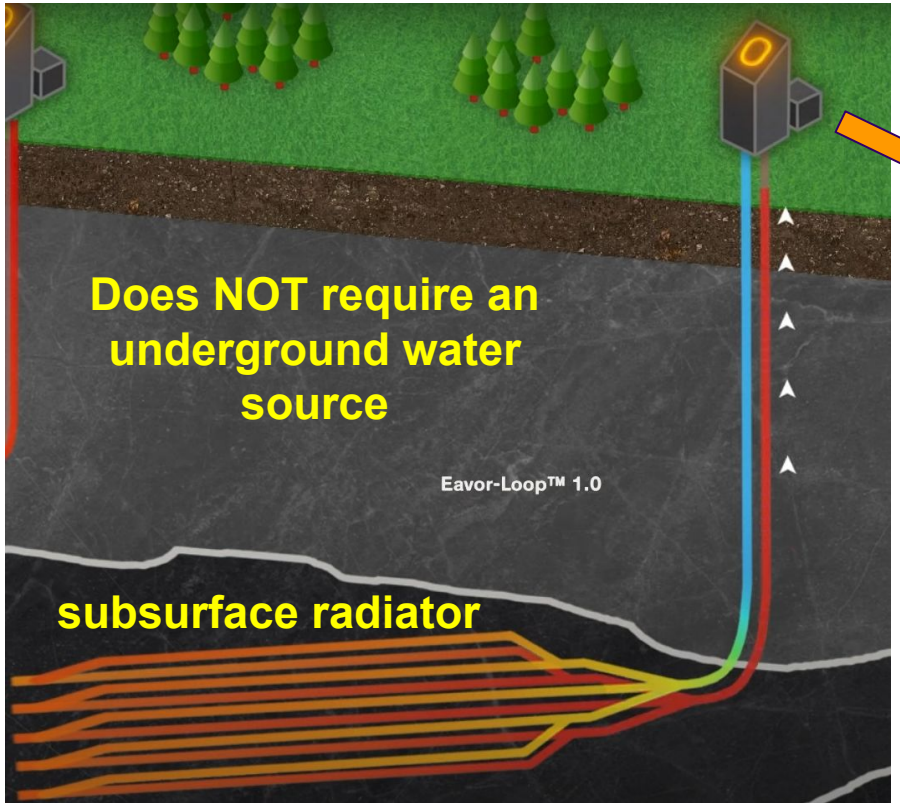
Closed loop geothermal electricity generation



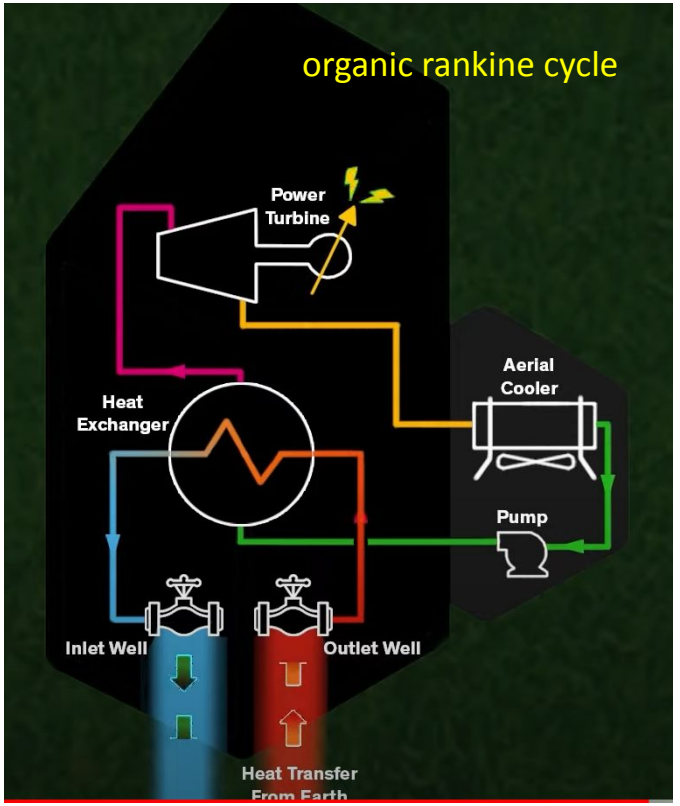
Does not require pre-existing hot water aquifer

Geothermal Phase 2 - AGT

Phase 2: Advanced Geothermal



Power plant at the surface



Advanced Geothermal electricity generation.

Drill closed loops in underground hot rock. Inject a surface fluid to extract heat from a subsurface radiator. Transfer that heat at the surface through a heat exchanger to a working fluid in a separate loop to drive an electric turbine.

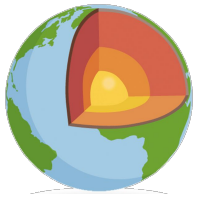
Eavor video https://www.youtube.com/watch?v=PtQmGPmyLA0

Sandia Labs Geothermal Research

Sandia's work in subsurface access, monitoring, and modification of the subsurface is aimed at the development of enabling technologies and reducing the cost and risk associated with drilling in harsh, subterranean environments.
A large portion of the cost and risk of generating electricity from geothermal sources is associated with drilling and completion of wells. Because of this, Sandia has primarily focused on developing improved drilling and completion technologies such as diagnostics while drilling, high-temperature electronics, advanced drill bit technologies, and wellbore integrity technologies to reduce and mitigate problems associated with loss of circulation.

- Computational modeling
- Enhanced Geothermal (EGS) collaboration
- Energetic simulation - drilling test rig
- Geothermal Energy and Drilling Technology
  - Hard rock drilling facility
  - High temperature electronics facility
  - HOT High Operating Temperature facility

https://energy.sandia.gov/programs/renewable-energy/geothermal-research/



Top Geothermal Energy Startups

We've spoken to Fervo and Eavor

Fervo Energy - **USA** | Funding: **$166M**

Fervo Energy commercializes proprietary technology to own, develop, and operate geothermal assets as the dispatchable foundation to a 100% clean energy future.

Eavor Country: **Canada** | Funding: **CA$85M**

Eavor's solution, Eavor-Loop, takes a traditional niche energy source (geothermal) and makes it scalable by removing the need for either volcanic-type temperature or permeable aquifers.

Quaise - **USA** | Funding: **$58M**

Quaise is an energy company pioneering millimeter wave drilling technology to access deep geothermal energy.

GreenFire Energy - **USA** | Funding: **$2.6M**

GreenFire Energy develops and deploys innovative technology to unlock the world's largest source of continuous renewable energy.

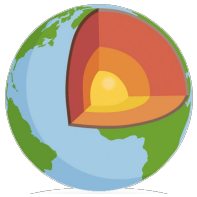
AltaRock Energy - **USA**|Funding: **$36.5M**

ARPA-e project AltaRock Energy focuses on the development of geothermal energy resources and Enhanced Geothermal Systems (EGS).

Sage Geosystems - **USA**

Sage combines innovative approaches to heat harvesting with modern oilfield expertise and methodologies to enable geothermal energy anywhere in the world

Tetra Corp **USA-Abq** drilling w/ pulsed power



Eavor NM Test Well in 2022

Eavor drilled (Aug-Dec ’22) the deepest and hottest directional geothermal well in history: Eavor-Deep™ at Lightning Dock, NM

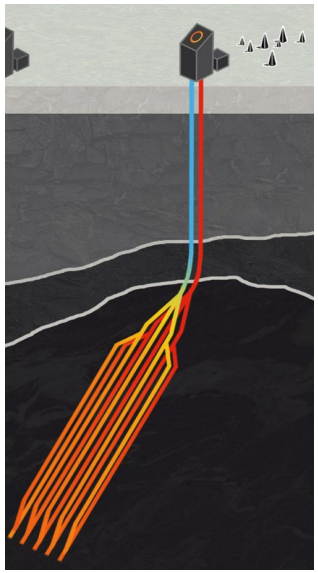
Demonstration well to advance technology to enable economic drilling in deeper and higher temperature rock.

“This well showcased Eavor’s proprietary drilling technology and demonstrated all the components required to construct commercial Eavor-Loops in deep, hot rock. **Achieved 18,000 ft depth & 250°C temps.**

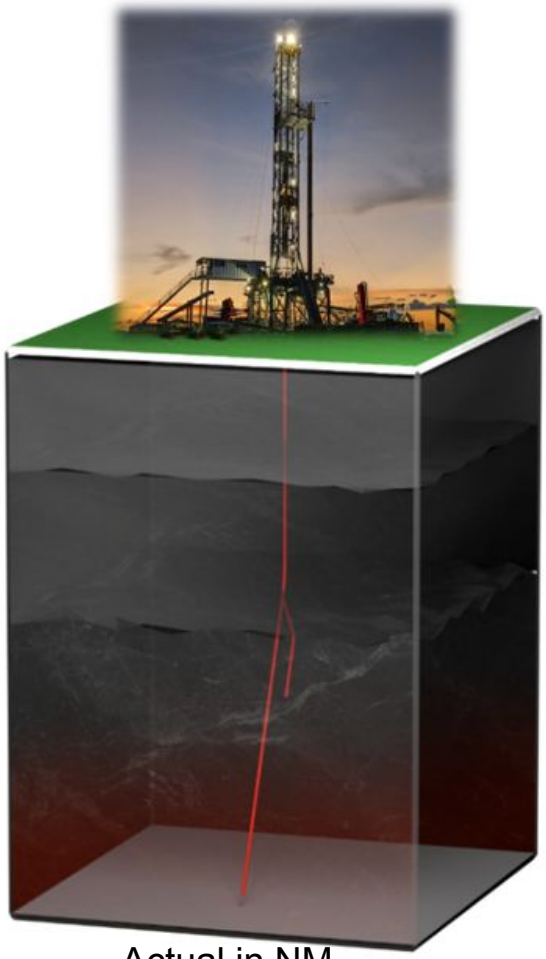
This is a key milestone that unlocks projects at locations in the US, Europe, and internationally.”

Eavor claims a path to “**sub-$60/MWh costs**”.

-Eavor was granted the construction and deployment of a **20MW** geothermal extraction system as part of **Nevada**’s energy strategy. - NV Energy Dec 2022
- Eavor signed agreement for up to 200MW closed loop geothermal plant in N. Calif. - Mar 2023



Concept



Actual in NM

https://www.eavor.com/press-releases/eavor-to-drill-the-deepest-and-hottest-directional-geothermal-well-in-history-eavor-deep/
https://www.eavor.com/blog/nevada-is-making-space-for-dispatchable-green-energy-amidst-energy-instability-in-the-southern-american-states/
https://www.thinkgeoenergy.com/eavor-signs-agreement-for-eavor-loop-geothermal-project-in-northern-california/

News: Fervo Energy Building Next-Gen Geothermal Plant in Utah

26-Sept-2023 Canary Media

"On Monday the Houston based startup Fervo Energy held a groundbreaking ceremony for its "**enhanced geothermal**" project in western Utah, which is expected to create **400 megawatts of 24/7 electricity** when it reaches full-scale production in **2028**."

Phase 1 to be operational in 2026.

Cape Station.com project

Located 12mi NE of Milford, UT

Fervo Energy breaks ground on next-generation geothermal plant

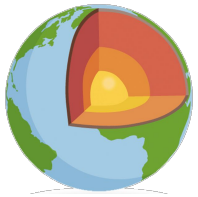
"Construction is underway on a new kind of geothermal plant — one that doesn't require the presence of hot springs or geysers to deliver carbon- free energy to the grid. Instead, the project developed by Fervo Energy is using powerful drills to reach over a mile down and access a more abundant form of subterranean heat."

https://www.canarymedia.com/articles/geothermal/fervo-energy-breaks-ground-on-next-generation-geothermal-plant

1st NM Geothermal Workshop 9/21/23

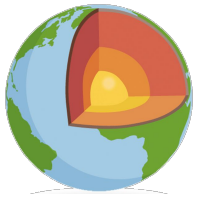
At NM Tech-Socorro Deju House conference center, organized by Dr. Shari Kelley.

Key workshop participants:
NM-Tech, Los Alamos Labs, Sandia Labs, NREL, NMSU, UNM, Fervo, Eavor, Envi-Trace, Geothermal Rising, with two industry panels including Shell & Devon energy.
> Need recurring 'Center of Ex' funding to continue.



Geothermal Development Hurdles

- Reduce delays in permitting, especially at the federal level.
- Create documentation to establish that upfront costs, though higher, translate to long-term benefits.
- Educate the public about geothermal possibilities and dispel misinformation.
- Establish a one-stop shop for geothermal data, permitting requirements, and other important information for developers.
- Engage utilities in designing transmission infrastructure for geothermal power plants in remote areas.

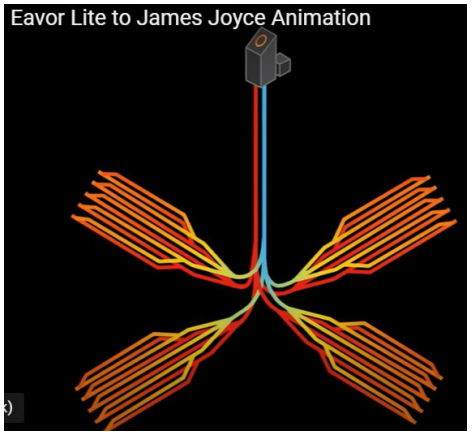


Geothermal Development Opportunities

Several themes were identified as opportunities that we can use to our advantage:

- An oil and gas workforce that can easily transfer their skills to the geothermal industry.
- A legislature that is interested in supporting geothermal development.
- The presence of elevated heat flow and geothermal resources in the Rio Grande rift.
- Geothermal expertise at the national labs and universities in New Mexico.
- A climate across much of the state that is appropriate for ground-source heat pumps for heating and cooling of buildings.

Summary



- New Mexico is #6 in geothermal resource potential
- It's clean energy for heat & electricity and a worthy investment for sustainable economic development
- Leverages skills & rigs from the oil industry
- Over $500M in federal funding to apply for
- **We request your support** for a 2024 geothermal development bill to better develop this NM resource.