



Unlocking Earth Heat: The Rise of Geothermal Energy and its Opportunities for the Oil & Gas Industry!

Will Pettitt, Executive Director, wpettitt@geothermalrising.org

March 18, 2021



GEOTHERMAL RISING

PREVIOUSLY GEOTHERMAL RESOURCES COUNCIL



MAY 25, 2020

NE NA SHANNON TERRY ANA QUILA GRETZ APRIL MAFRO ALEXANDER H REJA ZINER TWEN H DAN HEINBAESKY

ALL LIVES
MATTER
UNTIL
BLACK LIVES
MATTER

4 MUR
 4 CHARGES
 450 MILES

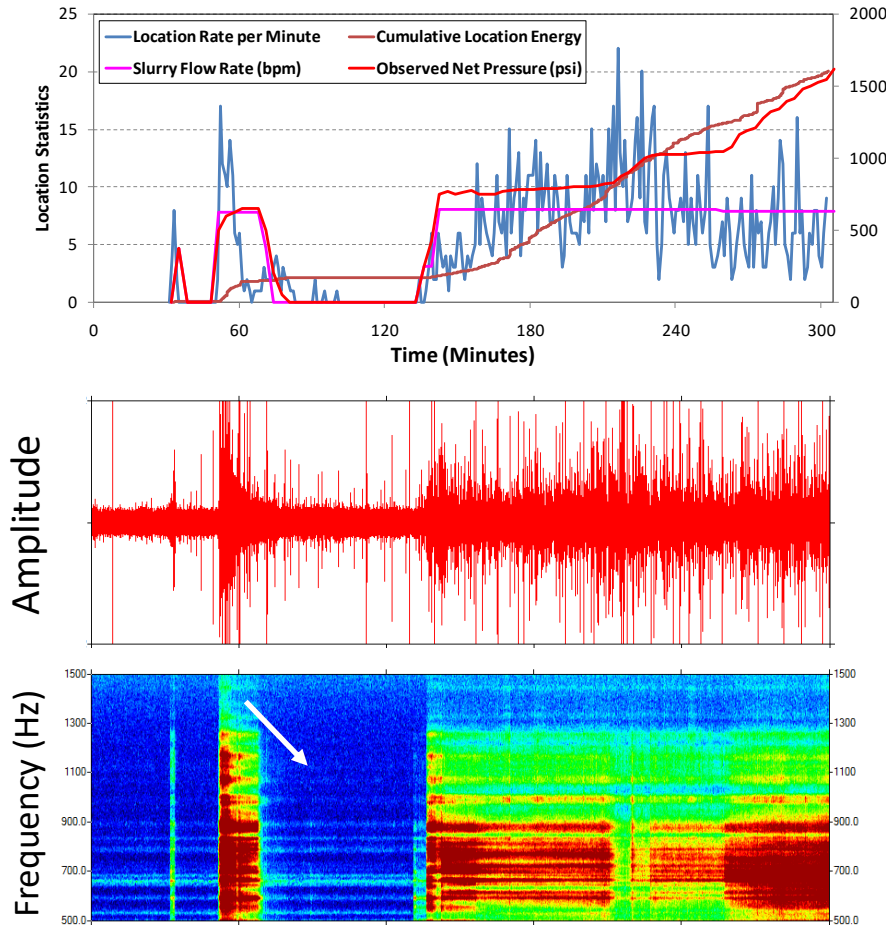


O&G with Geothermal – It's a natural fit!

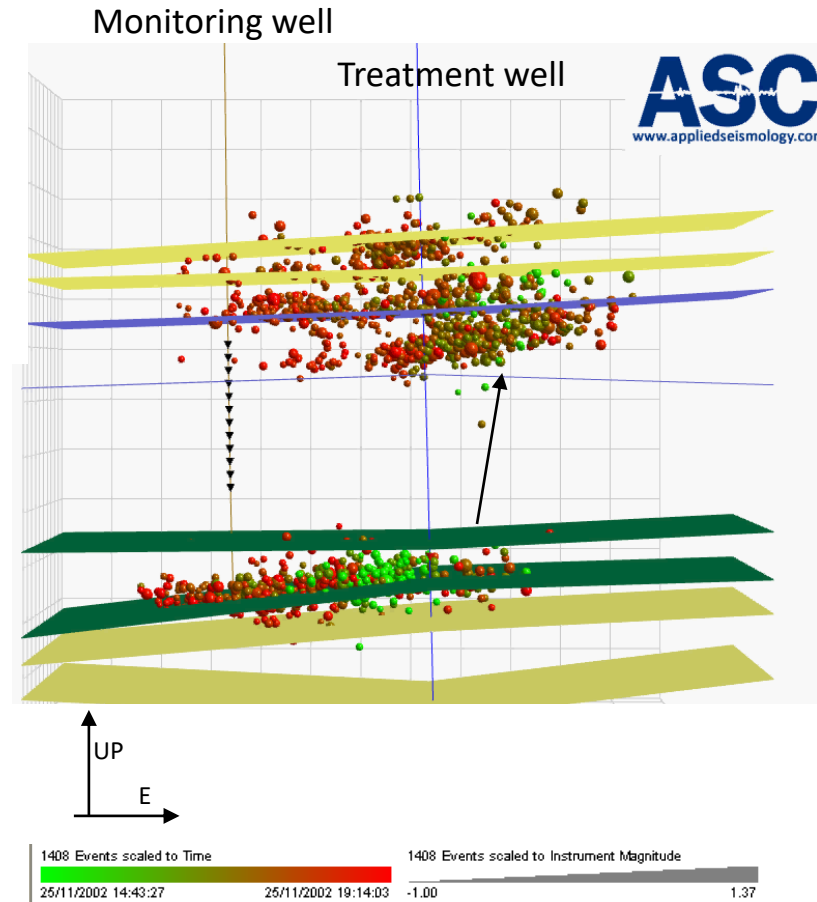




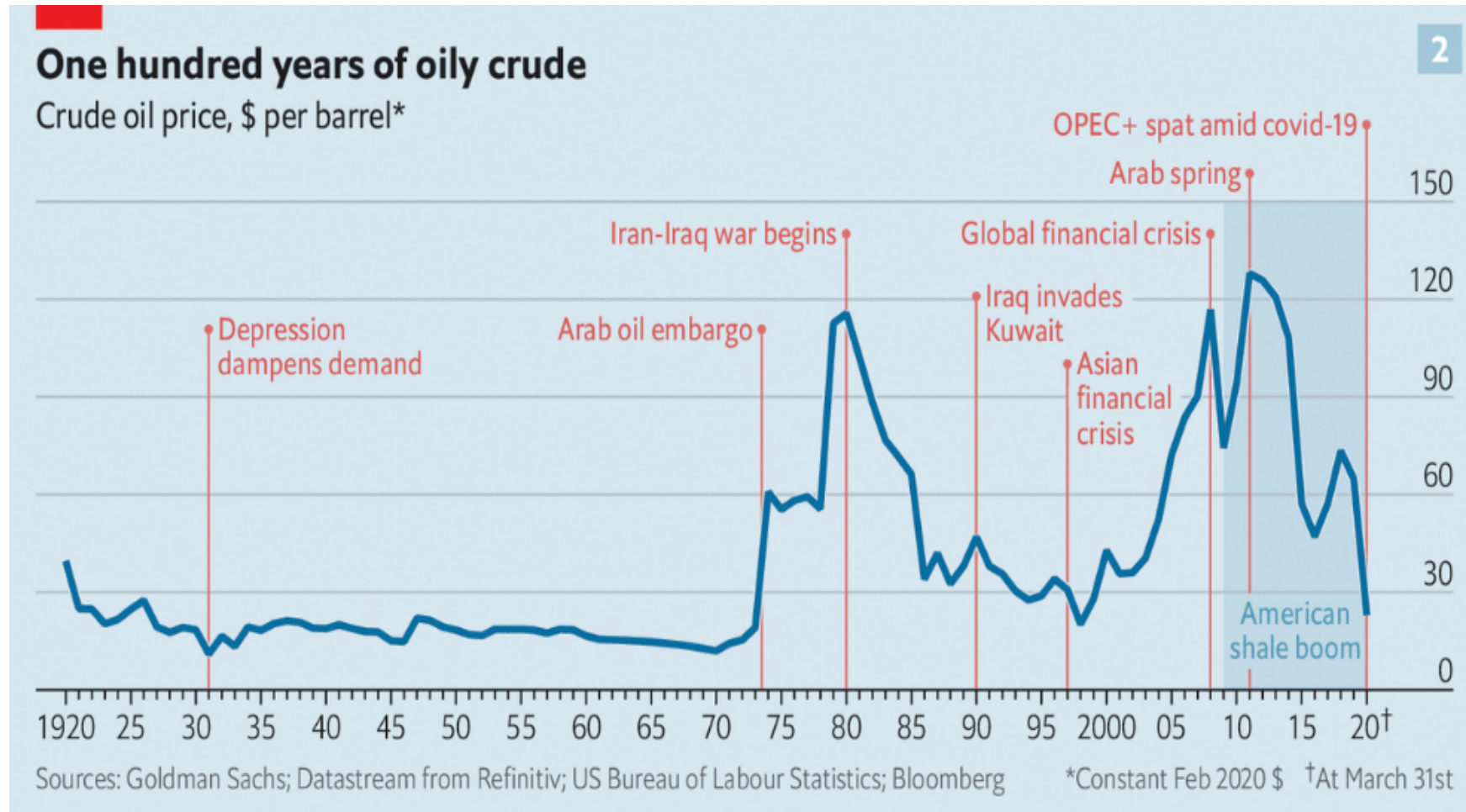
Continuous Microseismic Record



5 Hours Microseismic Monitoring



Sharma, M.M. Gade, P.B. Sullivan, R. Sigal, R. Fielder, R. Copeland, D. Griffin, L. and L. Weijers. Slick Water and Hybrid Fracs in the Bossier: Some Lessons Learnt. SPE ATCE, Houston 2004

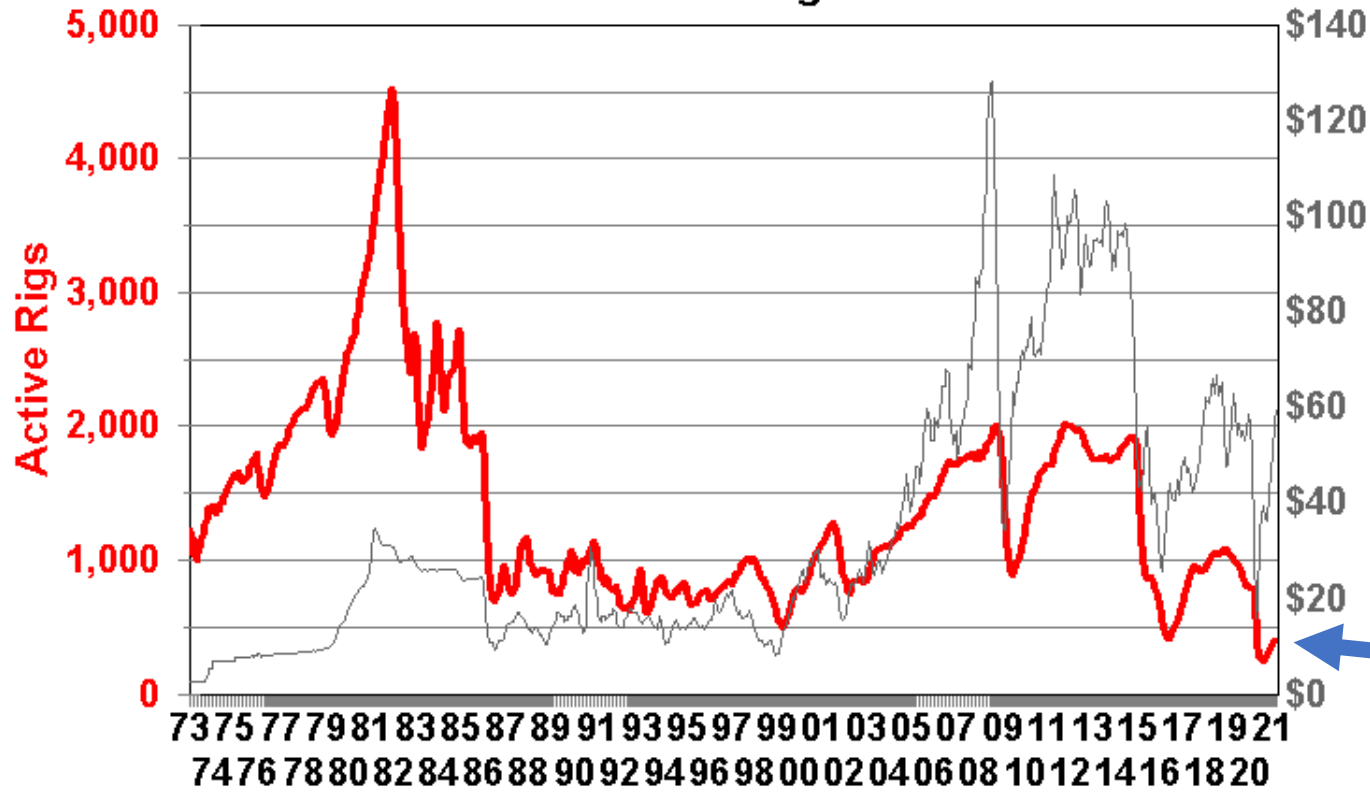


The Economist

An unprecedented plunge in oil demand will turn the industry upside down, The Economist, April 8, 2020. <https://www.economist.com/briefing/2020/04/08/an-unprecedented-plunge-in-oil-demand-will-turn-the-industry-upside-down>



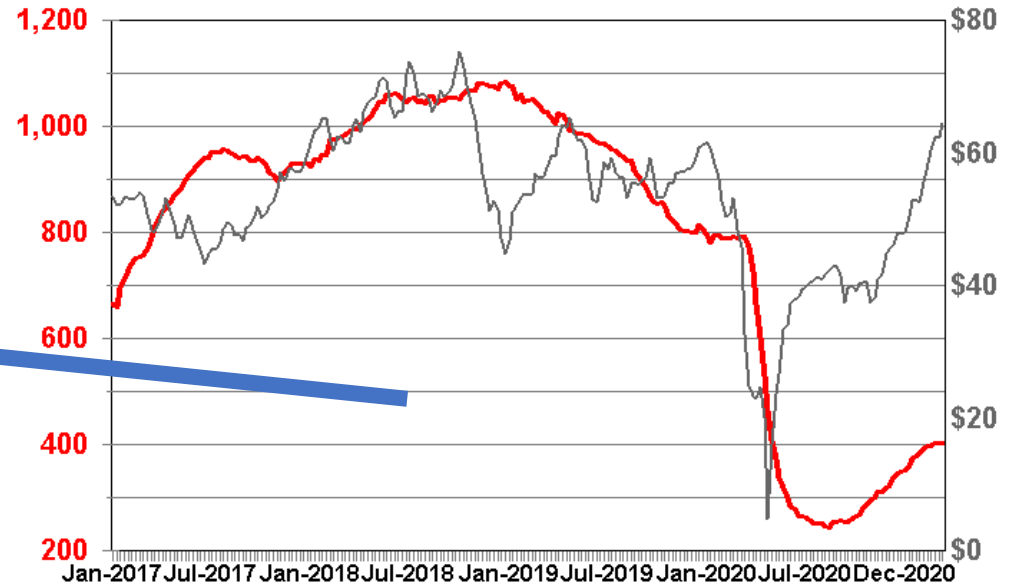
U. S. Rotary Rig Count Active Rigs



January 1973 - March 12, 2021

Sources: Baker-Hughes, Energy Information Administration (DOE), WTRG Economics ©2021
 www.wtrg.com
 (479) 293-4081

Crude Oil Price \$ / Barrel



January 2017 - March 12, 2021



A Win-Win Partnership!



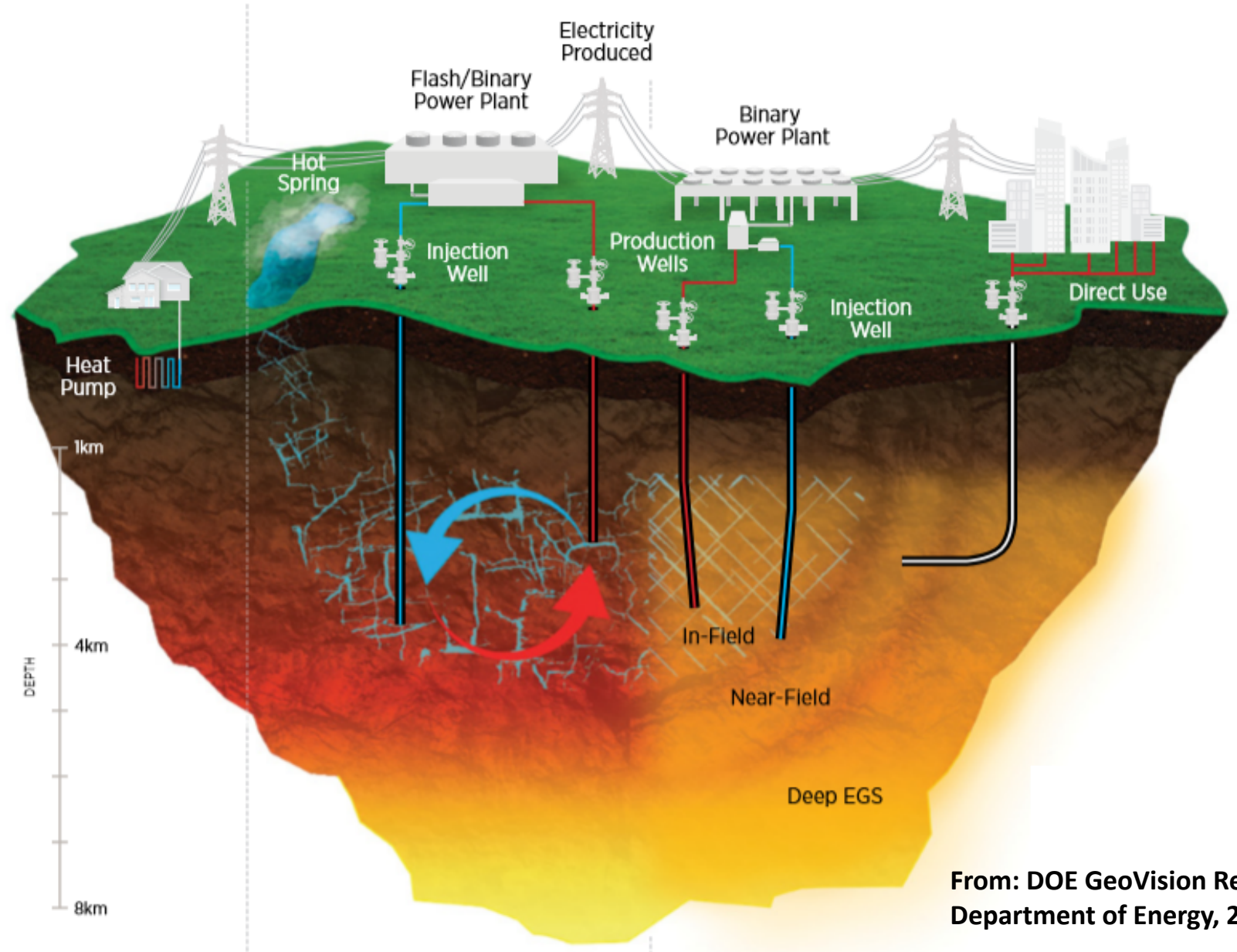
As Doug Hollett, former Acting Assistant Secretary for Fossil Energy recently noted:

“Geothermal uses many of the same services, technologies and personnel as the oil and gas sector. In the midst of this historically impactful oil and gas downturn, there is a unique opportunity to quickly leverage oil and gas capabilities and technologies into the geothermal sector while preserving jobs and regional economic viability, and ensuring US energy sector vitality.”

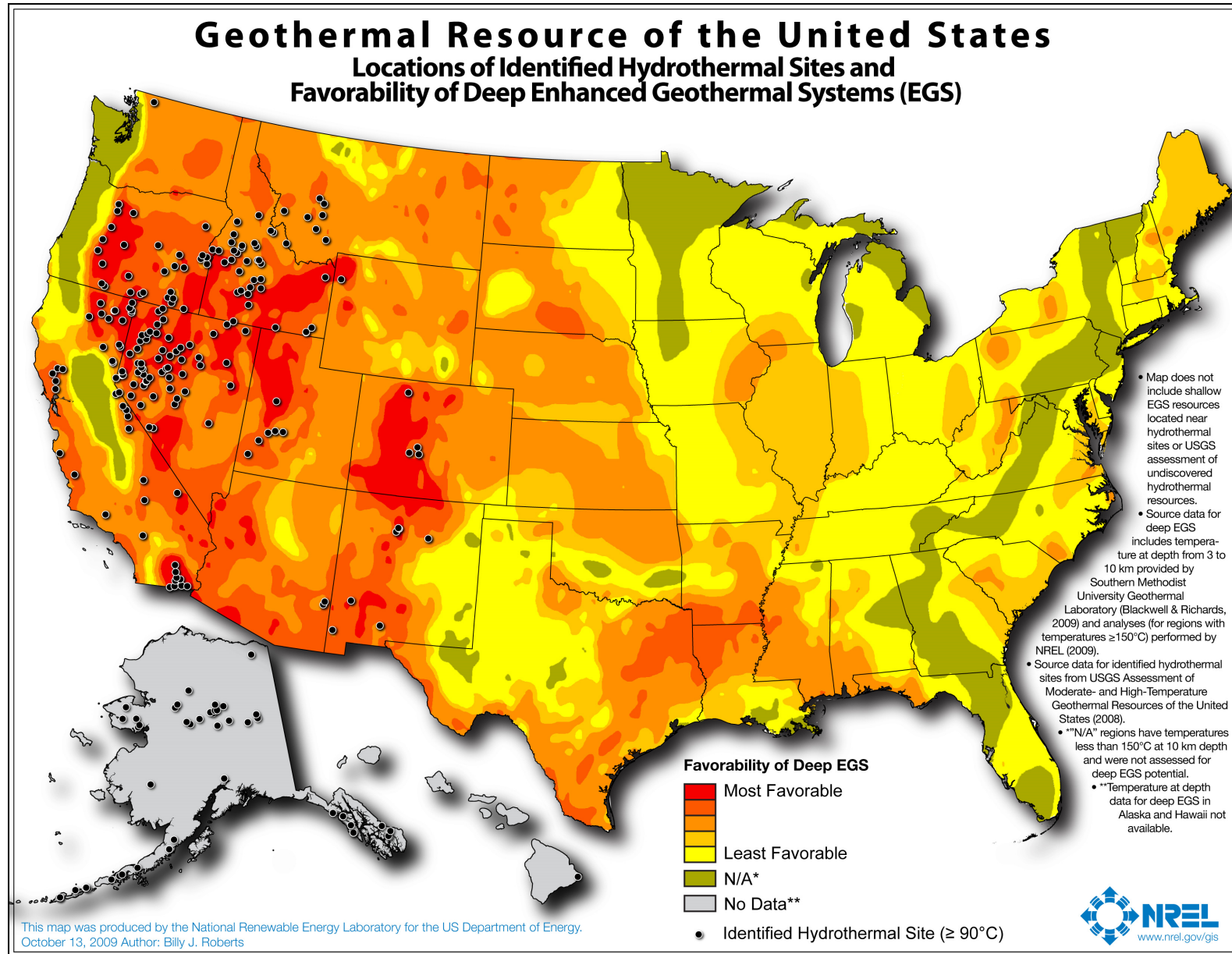


Geothermal Industries

1. Power Generation
2. Direct Use
3. Heat Pumps
4. New Technologies (EGS/AGS)



From: DOE GeoVision Report, Department of Energy, 2019



Installed conventional geothermal

3.8 GWe‡



Conventional geothermal under development

58 Projects*



Geothermal by 2050

60+ GWe**



Viable EGS potential
>>100 GWe***

‡ Pettitt et al., 2020

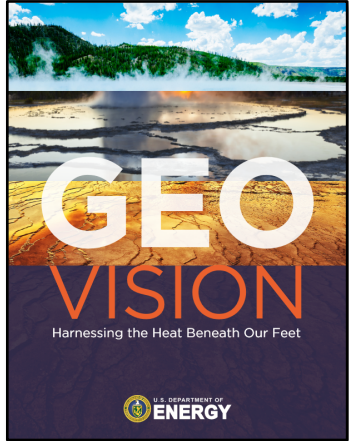
* Geothermal Rising, NREL, 2020

** DOE GeoVision, 2019

*** USGS, 2008

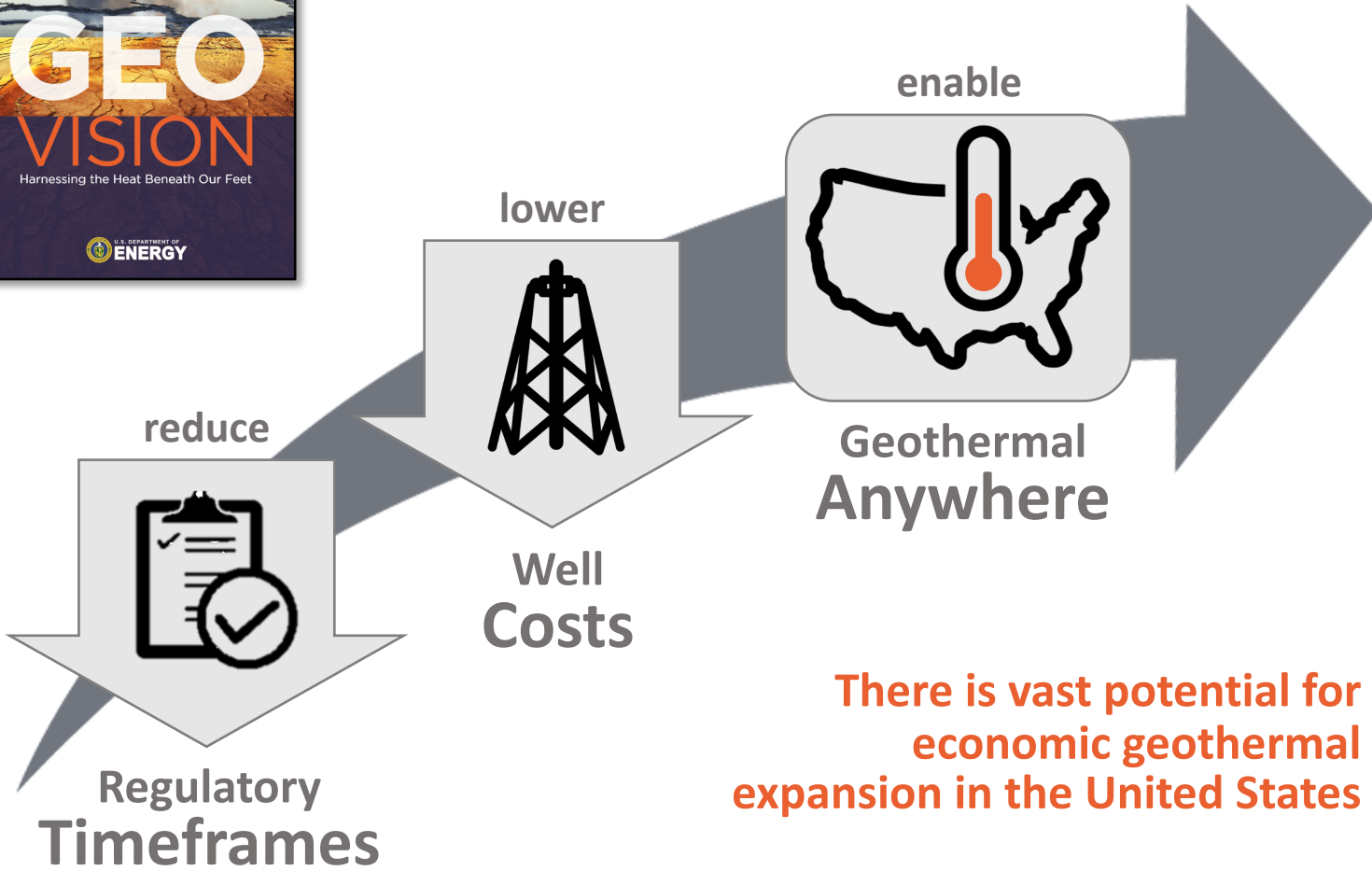
GeoVision

Harnessing the Heat Beneath Our Feet



www.energy.gov/geovision

Slide courtesy of NREL

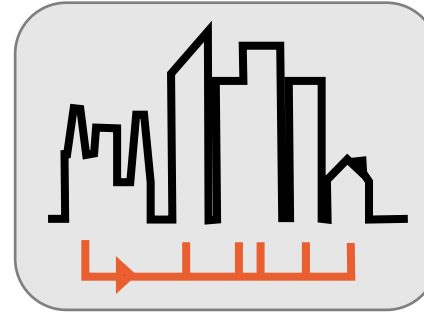


There is vast potential for economic geothermal expansion in the United States

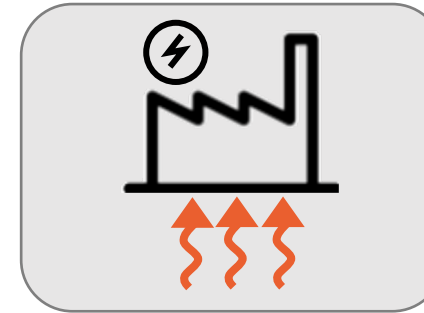
By 2050



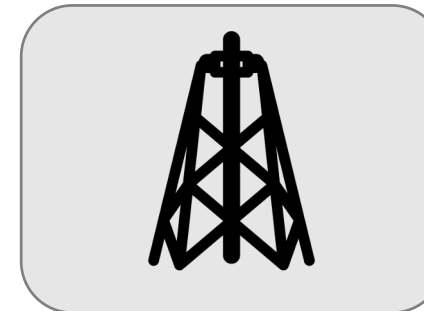
28 million
Geo Heat Pumps



17,500
District Heating Systems



60+ GW
Geothermal Power



10,000+
New Wells Per Year

Lets ask ourselves this...

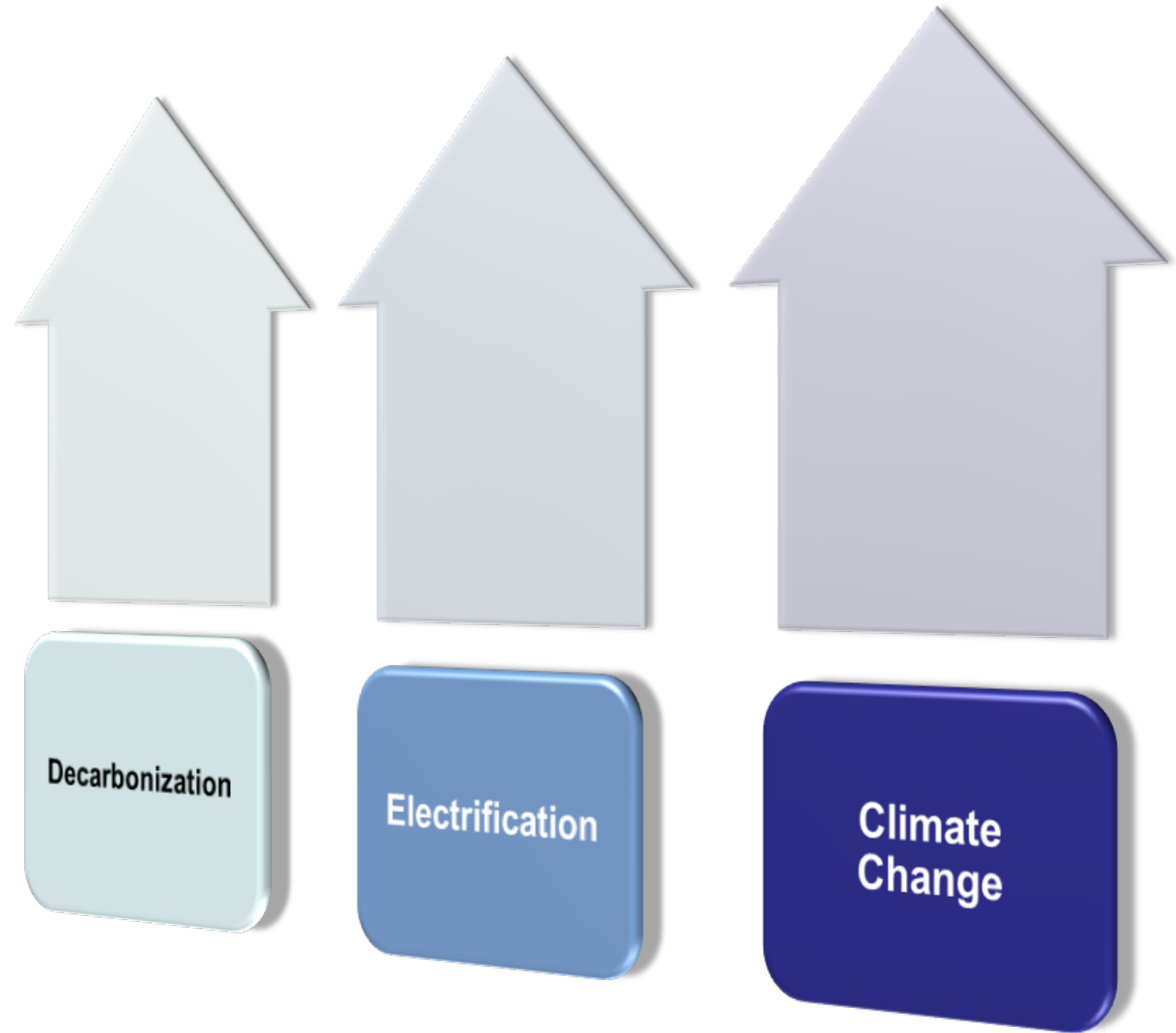
Where is my clean energy coming from
on a still, dark, winter night in 2030?

What about 2050?





What will be happening in 2030?

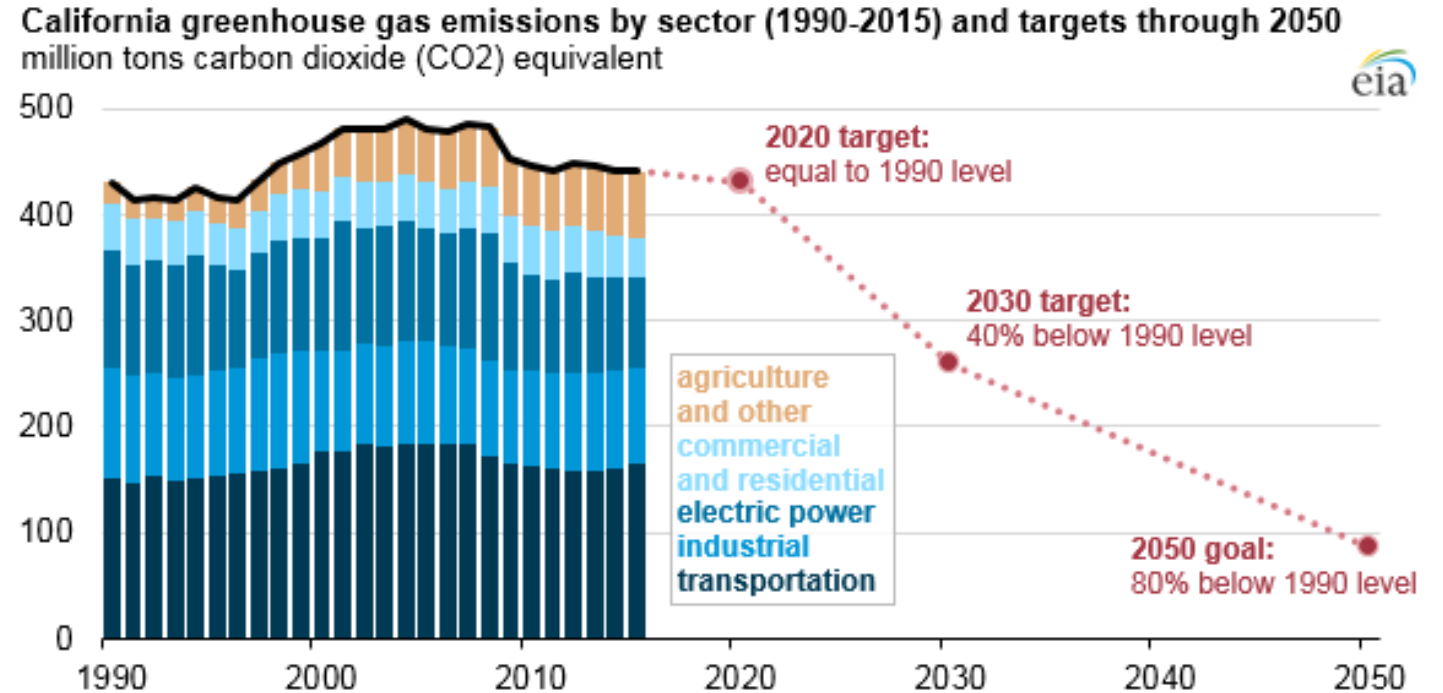




Fighting Climate Change – California RPS and GHG Targets

Legislation (SB 100) enacted in 2018 continued increasing RPS targets:

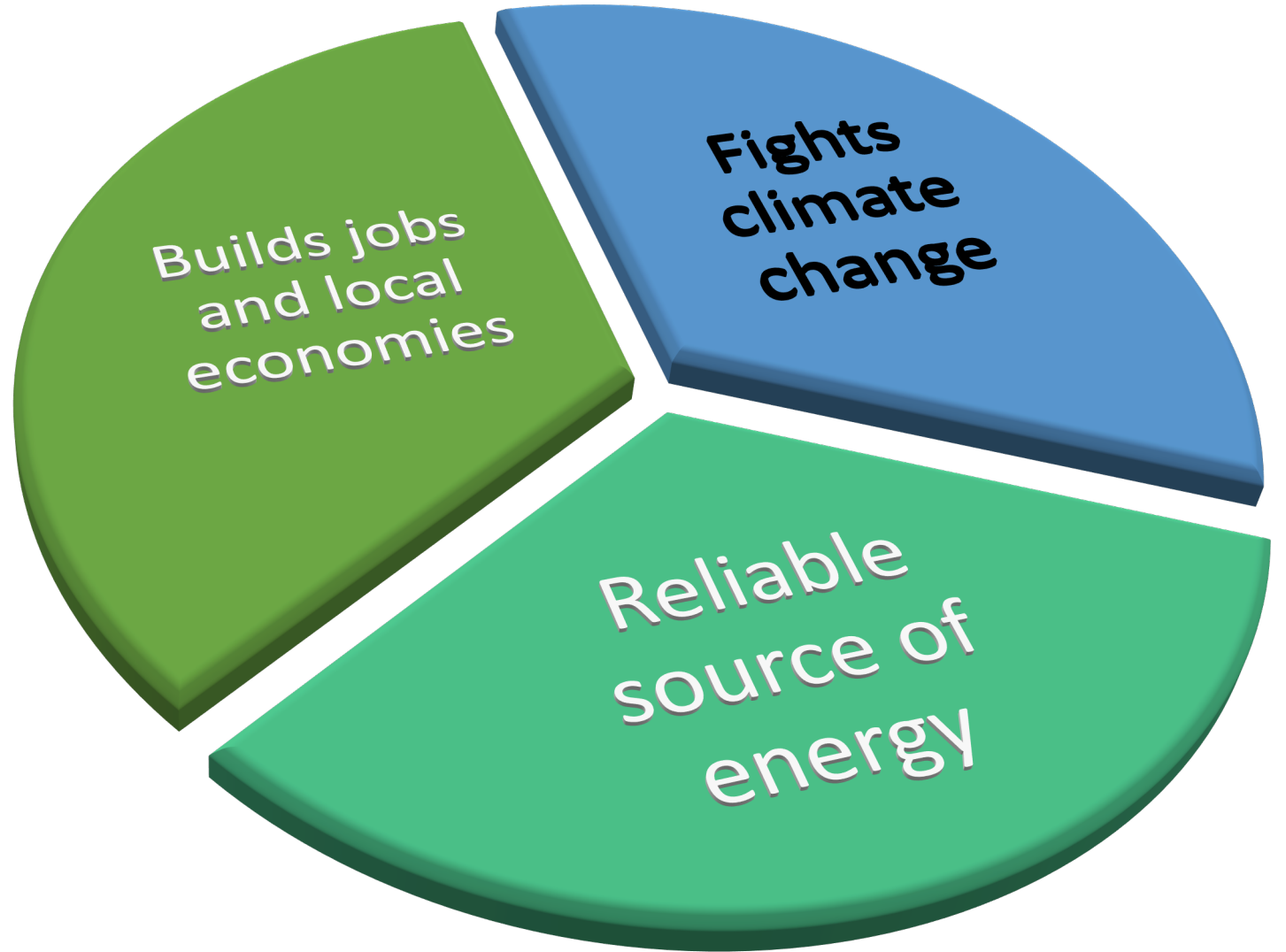
- 50 percent renewables by 2026
- 60 percent renewables by 2030
- 100 percent carbon-free energy by 2045



GHG targets enacted in 2017
legislation (AB 32) and previously



What does Geothermal Bring?





Geothermal is 24/7 always on

Renewable Energy that Works Around the Clock

- Clean
- Reliable
- Flexible
- Balancing
- Resilient
- Stable
- Facilitator



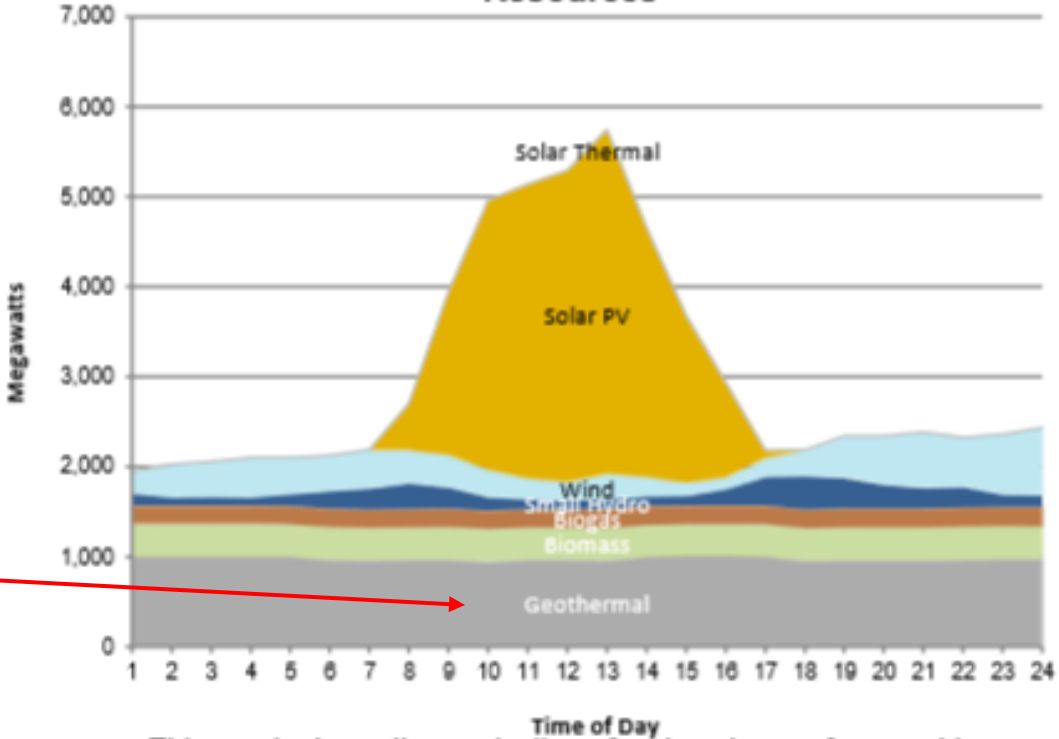
Geothermal as Baseload in California

24-Hour Renewables Production

Renewable Resources	Peak Production Time	Peak Production (MW)	Daily Production (MWh)
Solar Thermal	12:57	34	0
Solar	12:17	4,162	21,624
Wind	23:59	768	9,152
Small Hydro	18:04	375	4,365
Biogas	23:44	214	5,033
Biomass	3:20	375	8,752
Geothermal	16:49	1,001	23,376
Total Renewables			72,301

Total 24-Hour System Demand (MWh): 603,072

Hourly Average Breakdown of Renewable Resources



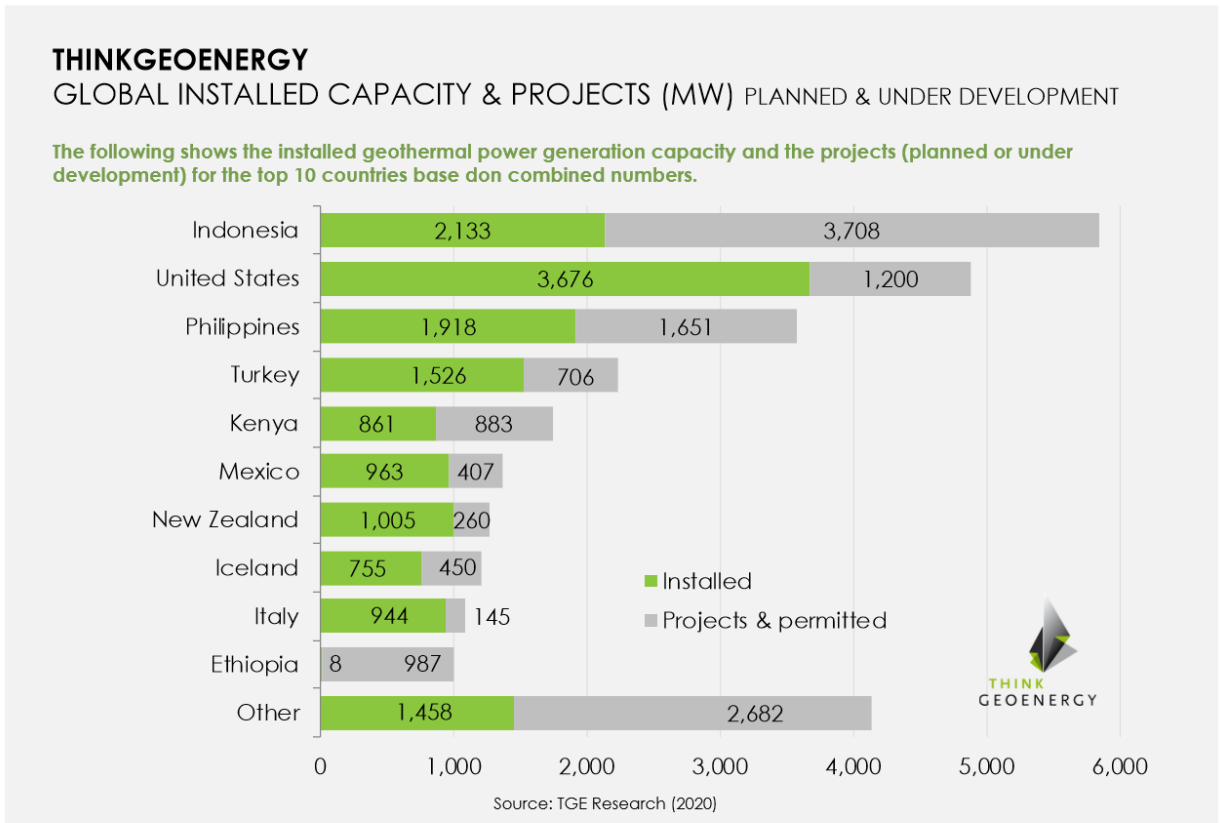
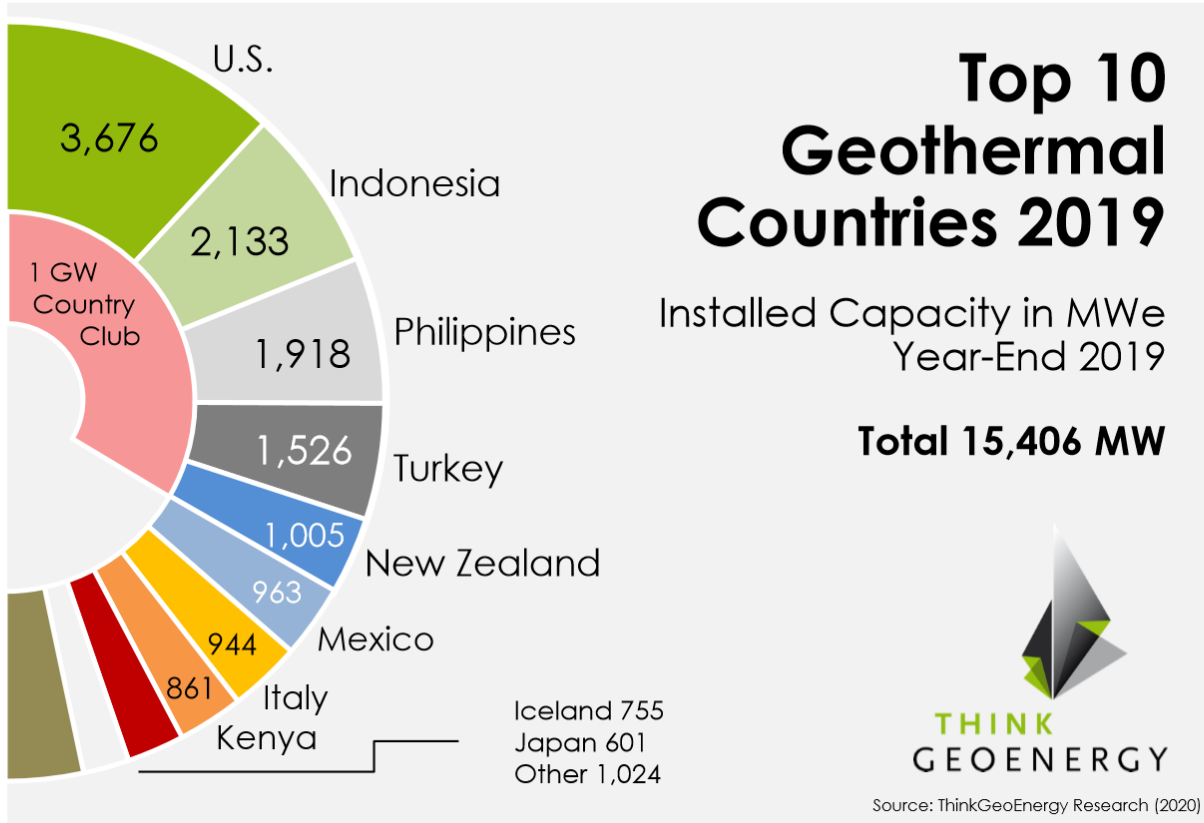
This graph shows the production of various types of renewable generation across the day.

Renewables Watch for 10th December, 2018, California Independent System Operator, www.caiso.com

System Peak Demand (MW) 30,061
 *one minute average
 Time: 17:53



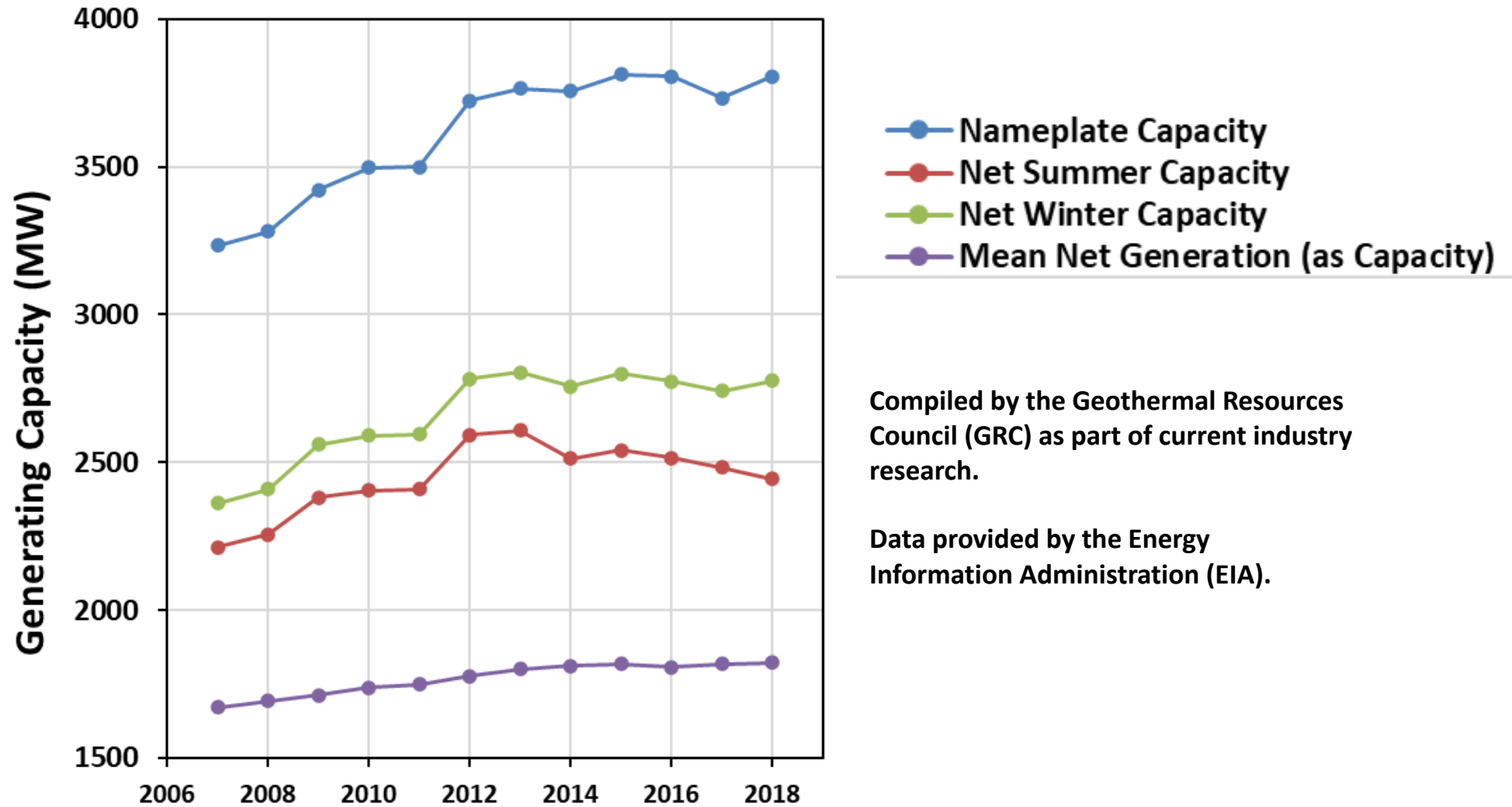
International Market Growth



Graphics courtesy of ThinkGeoEnergy – data from various sources



US Resource Development



Compiled by the Geothermal Resources Council (GRC) as part of current industry research.

Data provided by the Energy Information Administration (EIA).

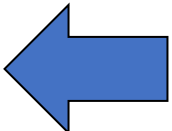
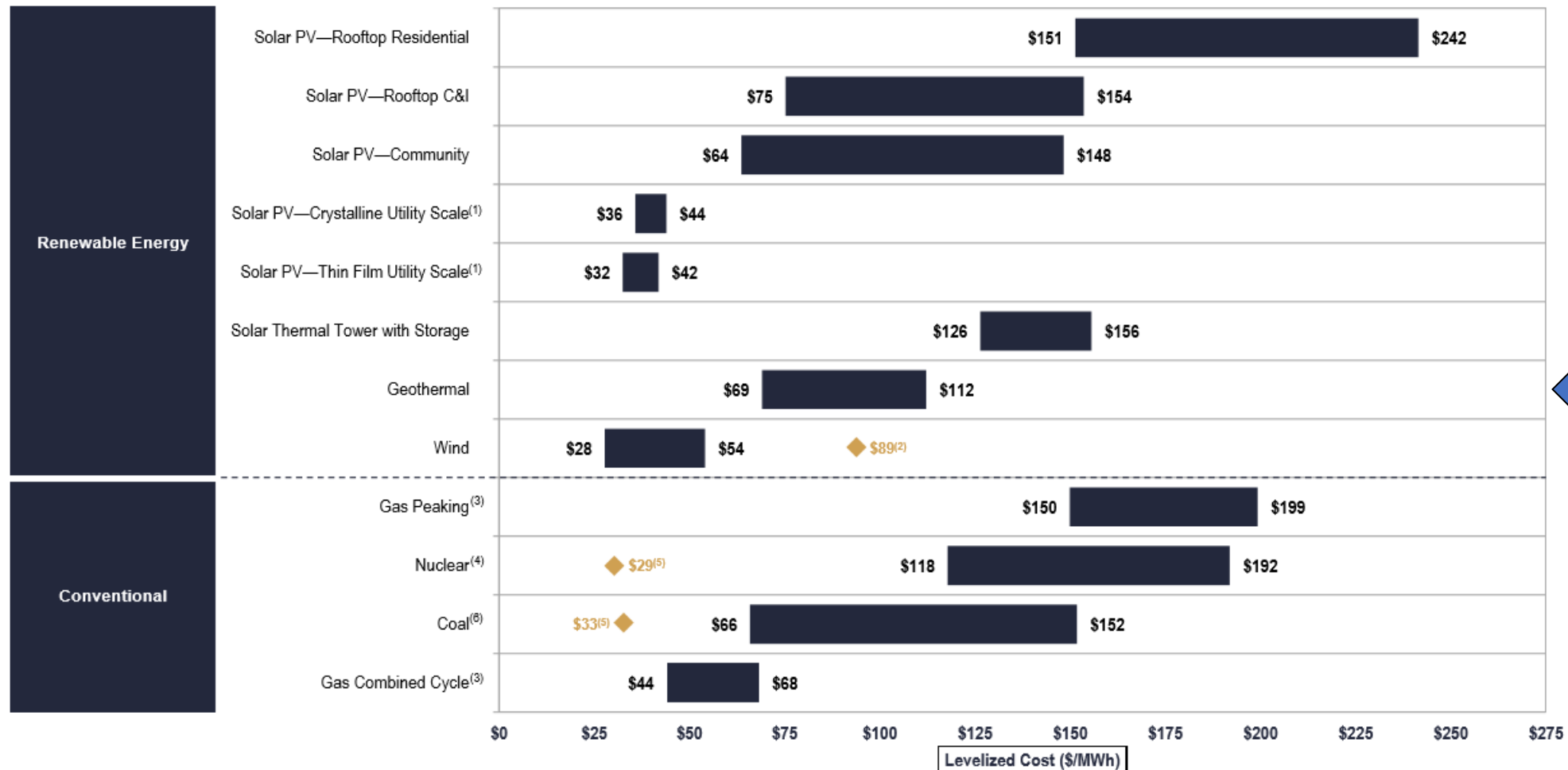


LAZARD

LAZARD'S LEVELIZED COST OF ENERGY ANALYSIS—VERSION 13.0

Levelized Cost of Energy Comparison—Unsubsidized Analysis

Selected renewable energy generation technologies are cost-competitive with conventional generation technologies under certain circumstances





Geothermal Power Purchase Agreements



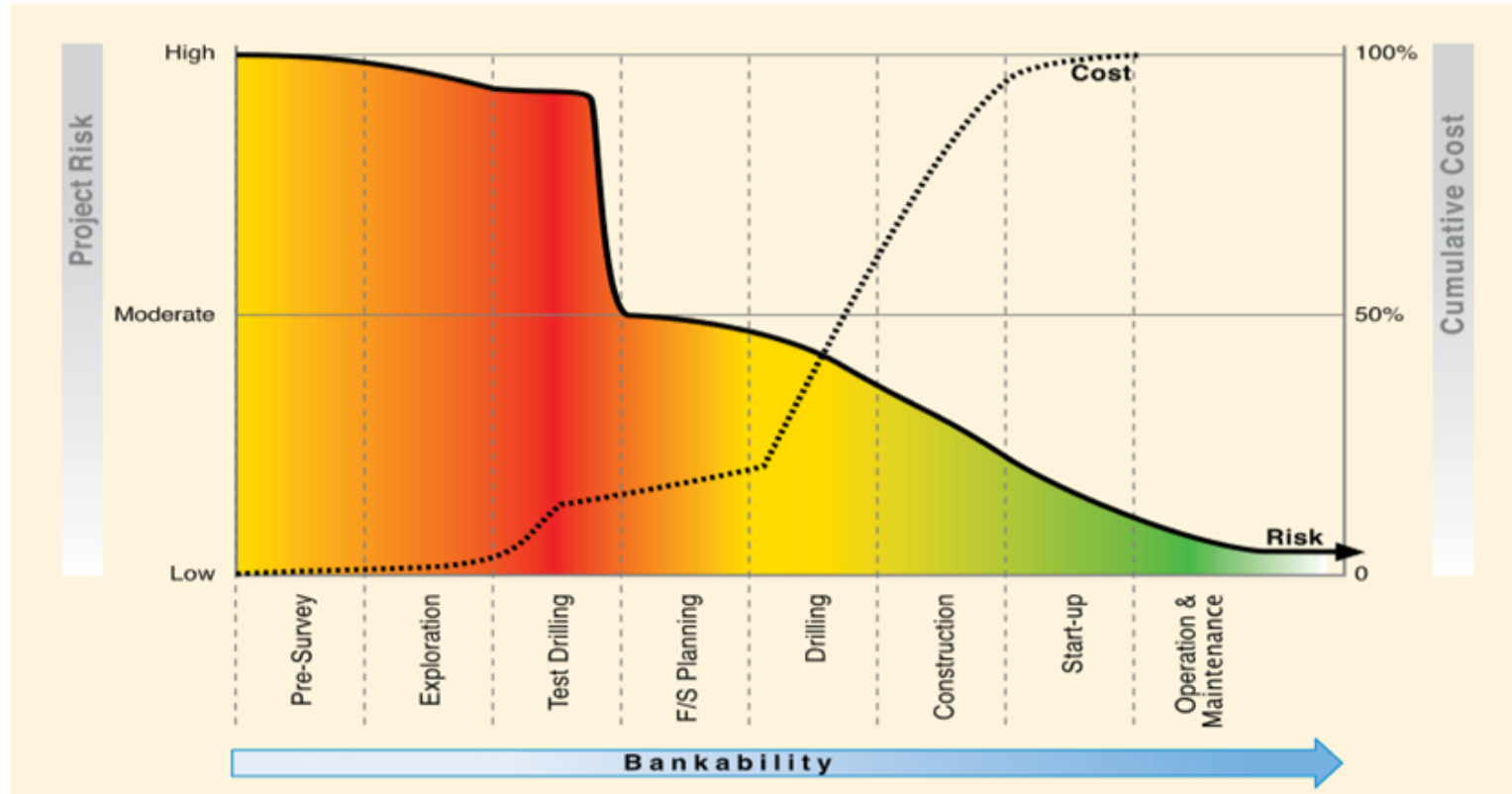
- Hell's Kitchen 40MW for 25 year term \$74
- Whitegrass 3MW for 25 year term \$67.50
- Star Peak 12.5MW for 25 year term \$70.25
- Casa Diablo 16MW for 20 year term \$68
- Puna 46MW for 30 year term \$70
- Soda Lake and Coso pricing not public

<https://www.nrel.gov/docs/fy21osti/77774.pdf>



Risk picture similar to O&G industry

Project cost and risk profile for geothermal development stages



Source: World Bank/ ESMAP, TGE Research (2017)

Technology Development

- **Reduce up-front project risk**
- **Drilling Cost Efficiencies**
- **Site and Resource Evaluation**
- **High-temperature Drilling**
- **Hydraulic Stimulation Design**
- **High-temperature Downhole Tools and Borehole Control**

U.S. DOE's Frontier Observatory for Research in Geothermal Energy (FORGE)

What is FORGE?

A flagship initiative (\$190M to date) to design and test a **breakthrough approach** to developing large-scale, economically sustainable EGS reservoirs, helping unlock over 100 GW_e of domestic geothermal energy.



- Funded by DOE's Geothermal Technologies Office (GTO)
- Utah FORGE released its first R&D solicitation (up to \$46M) in April 2020, with project selection announcement expected in February.
- Recently completed drilling of the first production/ injection well; the well was drilled 50% faster as a result of careful planning, advanced bits, and specialized-training and support from TAMU through a separate GTO R&D award.



Photo: Joseph Moore

Low-Temperature Geothermal Technologies

Geothermal Heat Pumps

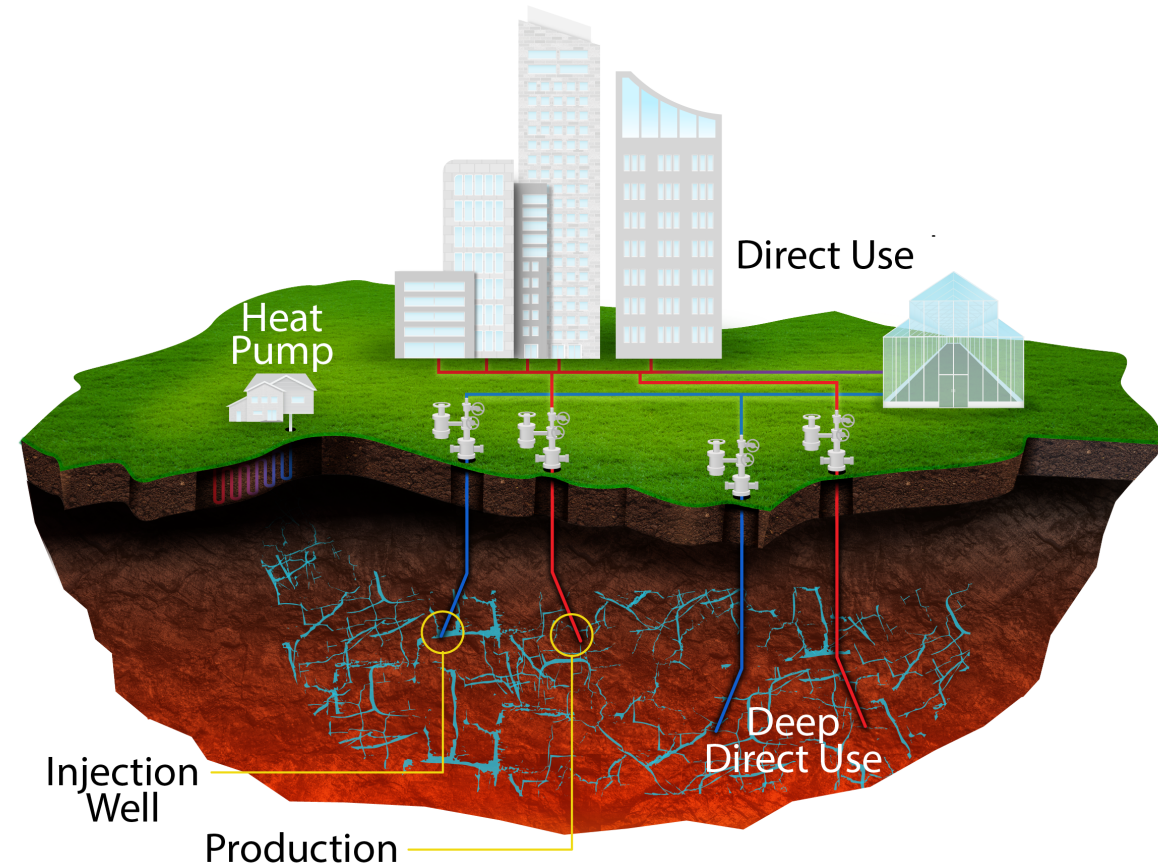
- Entering Water Temp (40-80° F)
- Shallow trenches to wells hundreds of feet deep
- Residential, light commercial

Direct Use and Thermal Energy Storage

- Entering Water Temp (80-300° F)
- Wells hundreds to thousands of feet deep and Saline or Brackish Aquifers
- Large buildings, agriculture

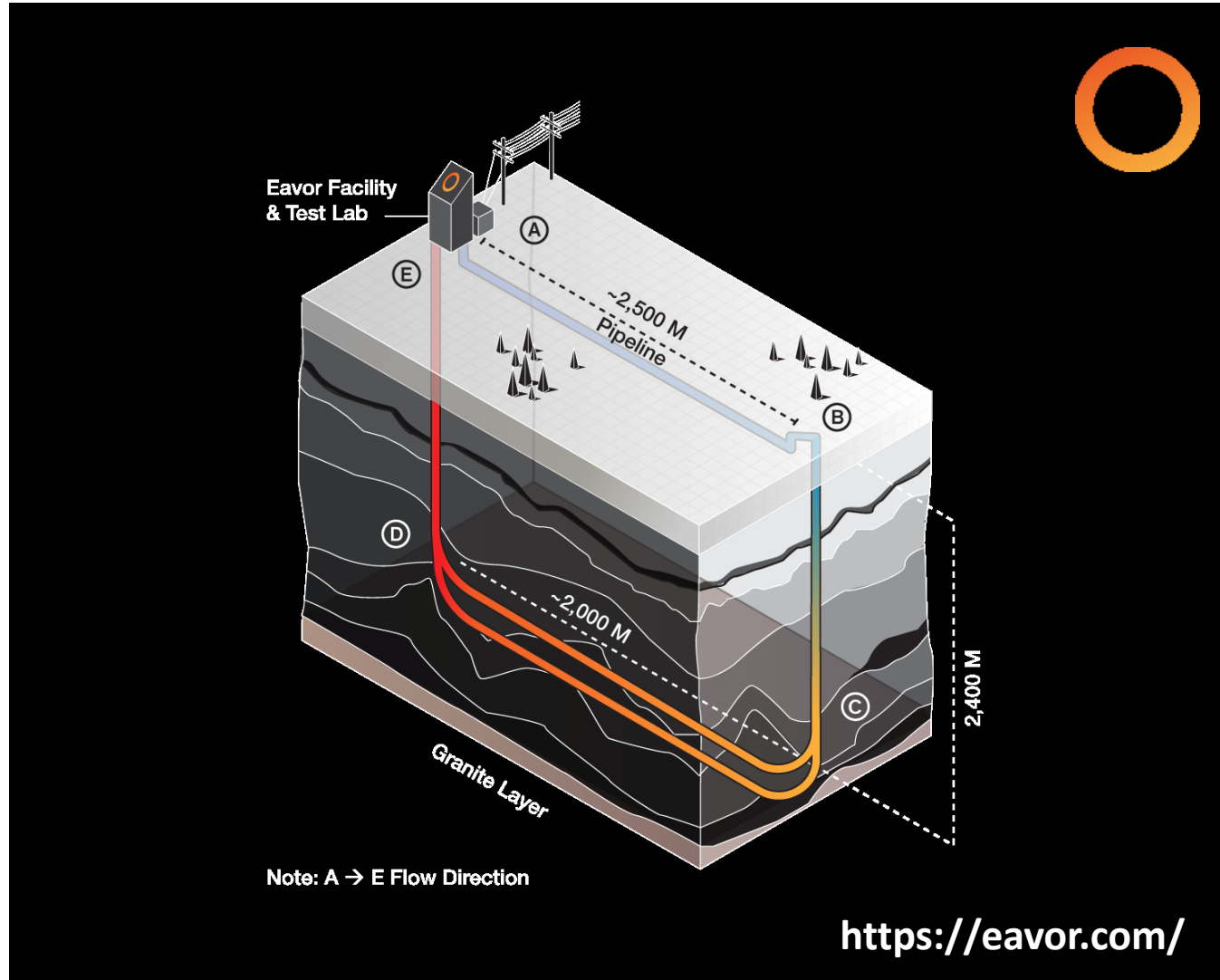
Electric Power

- Entering Water Temp (>150° F)
- New Organic Rankine Cycle Modular
- Distributed off-grid power





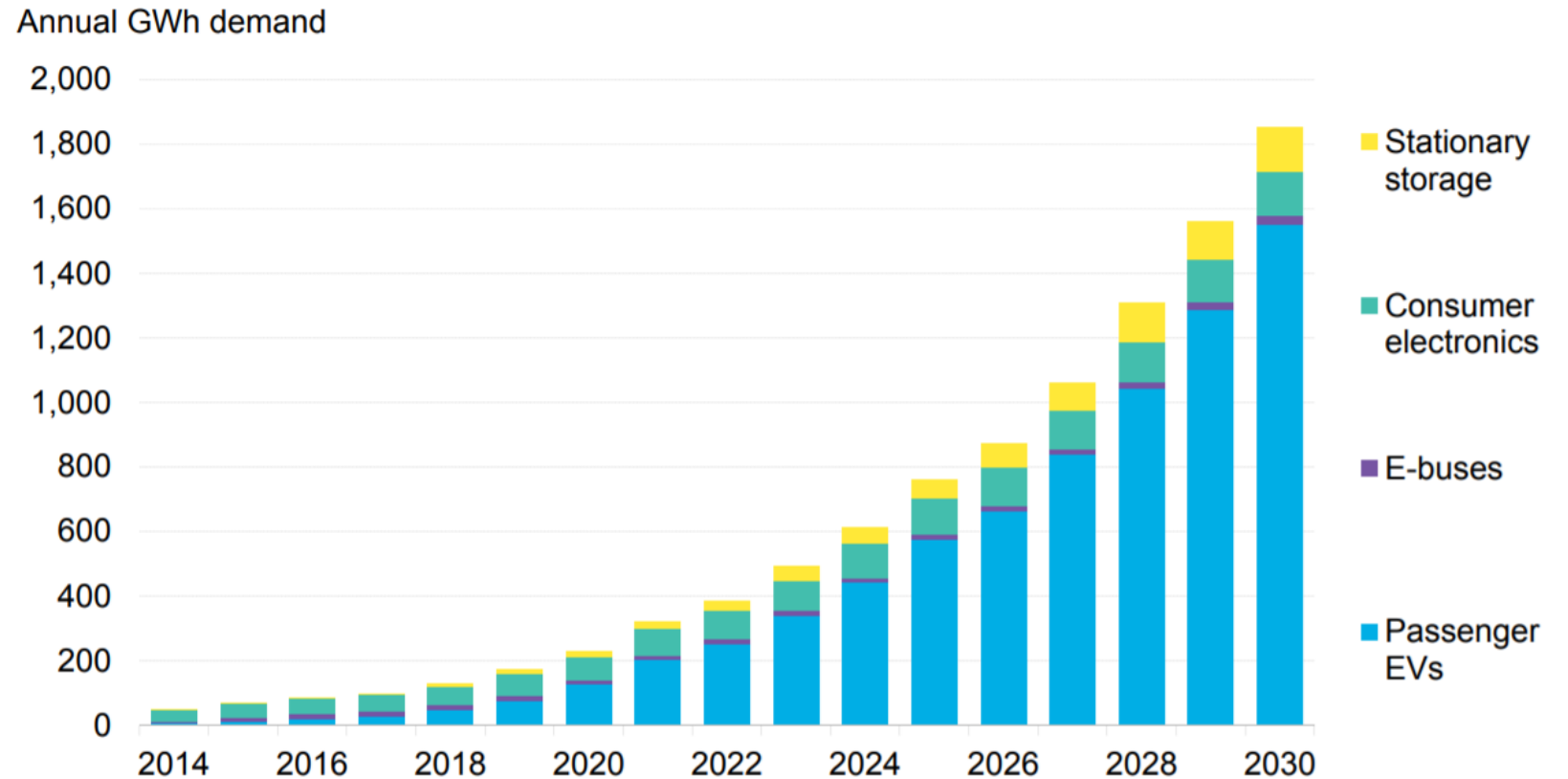
Closed-Loop Technologies





Annual Lithium-ion Battery Demand

Berkshire Hathaway Energy – Geothermal development in Southern California could also supply over two-thirds of the world’s lithium demand in 2025! And at competitive cost...



Source: Bloomberg NEF

4 November 15, 2018

BloombergNEF



Oil & Gas Co-production

- Technically viable but economically challenged;
- Co-Production with Oil & Gas Operations;
- Retrofit or Re-Purpose Existing Petroleum Wells;
- Advantage of scale.



Policy Committee

Advocates for public policies that will promote the development and utilization of geothermal resources

- A forum for the industry to discuss relevant issues;
- Companies across a broad spectrum of the geothermal power industry;
- Add-on option to fund advocacy work at the State, Federal and International levels.



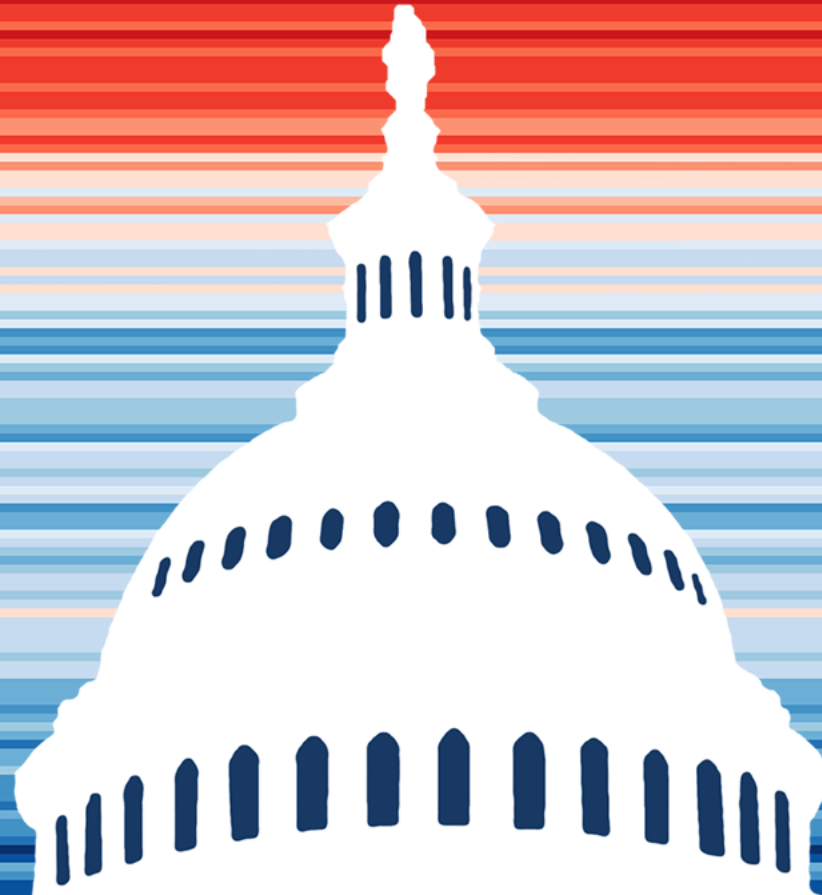


Energy Act of 2020

Advanced Geothermal Innovation Leadership (AGILE)



- Increased research, including EGS, drilling, technology transfer, subsurface computer simulations;
- Establishing more FORGE-type sites, including east of Mississippi;
- Investigating streamlined permitting processes for geothermal exploration and leasing activities;
- Development of coproduction with petroleum and mineral industries.



SOLVING THE CLIMATE CRISIS

The Congressional Action Plan for a Clean Energy Economy and a Healthy, Resilient, and Just America



Thank You!