U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Geothermal Technologies Office: Reservoir Thermal Energy Storage (RTES) Portfolio

Jeff Bowman

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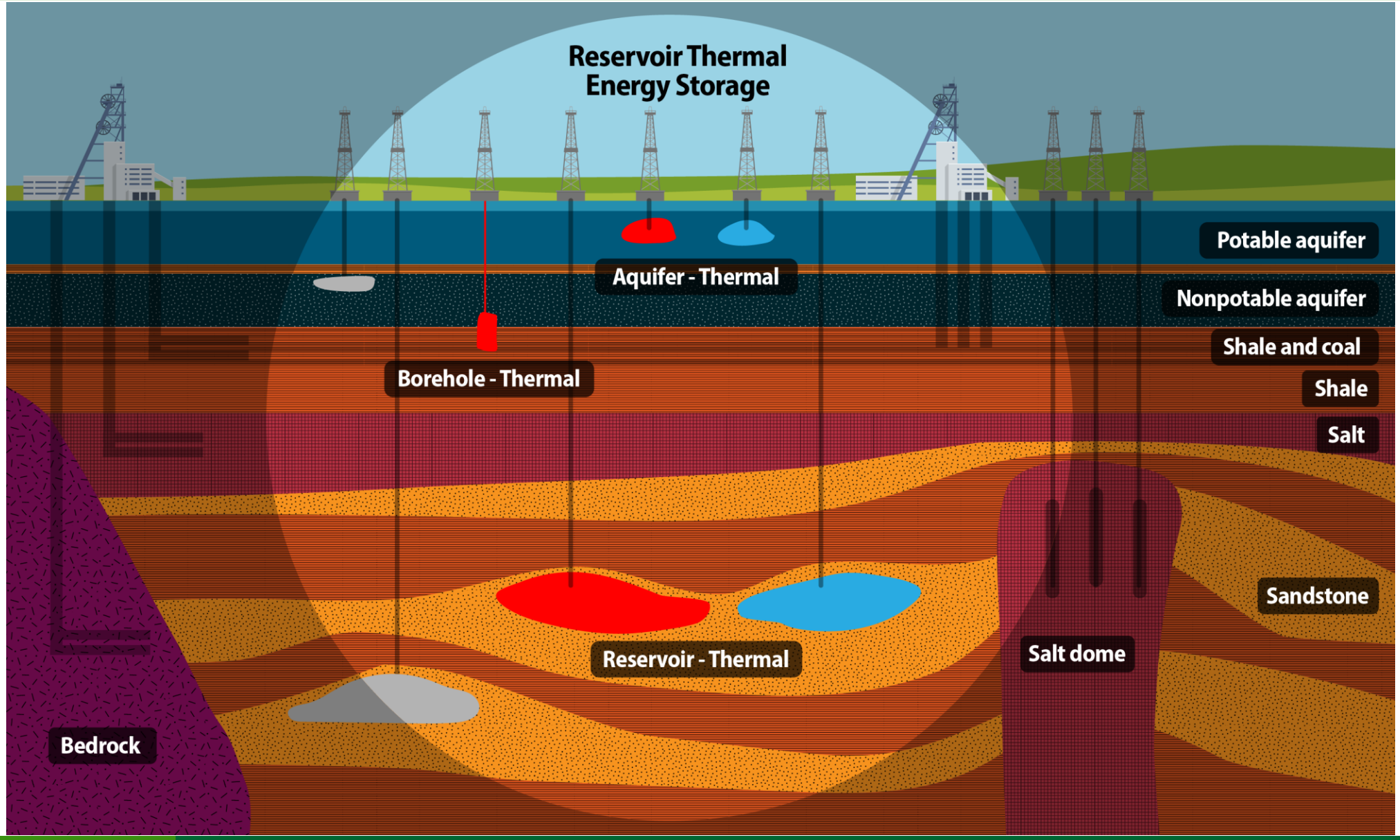
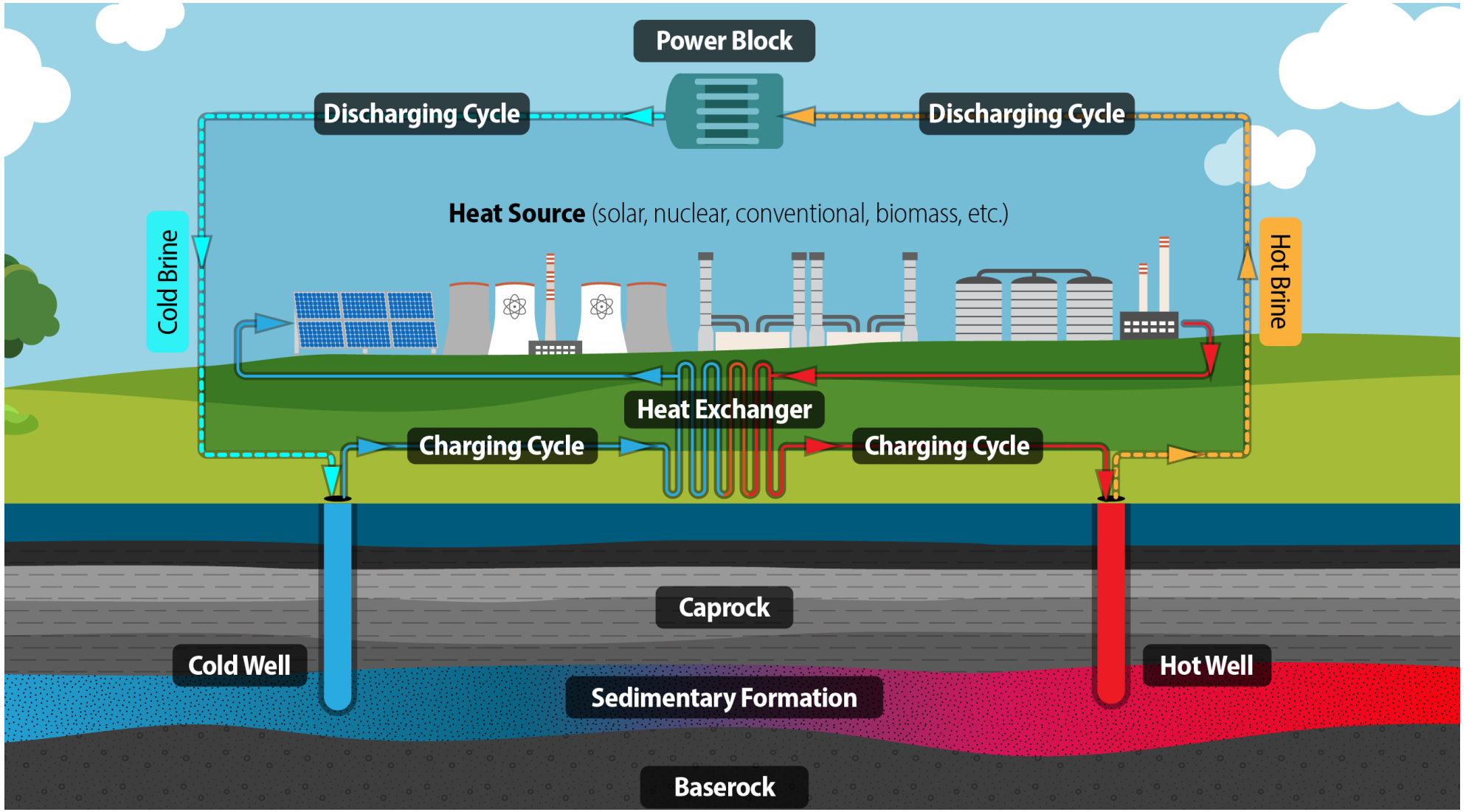
Geologic Energy Storage Methods

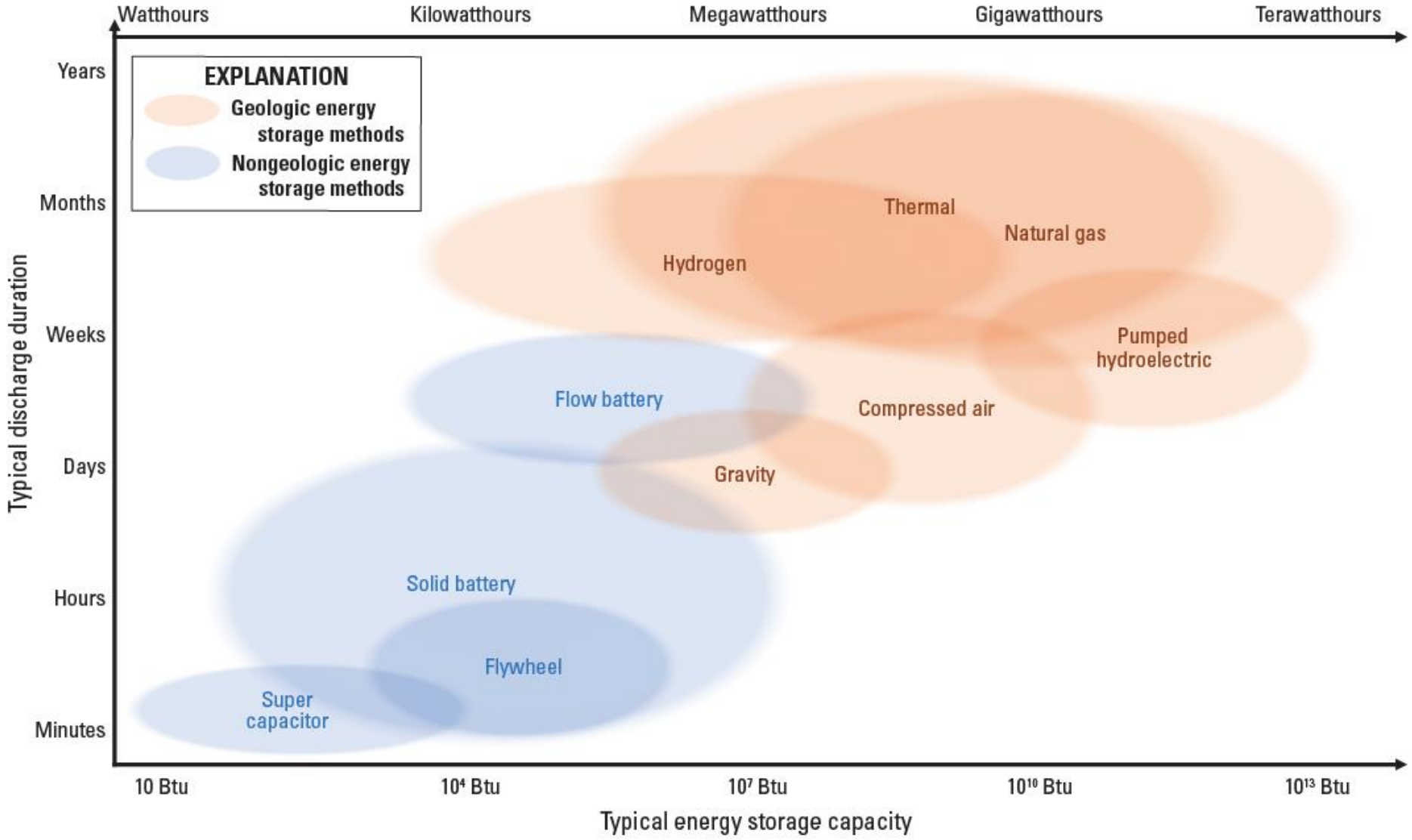
Adapted from
https://pubs.usgs.gov/fs/2022/3082/fs20223082.pdf



Reservoir Thermal Energy Storage (RTES)



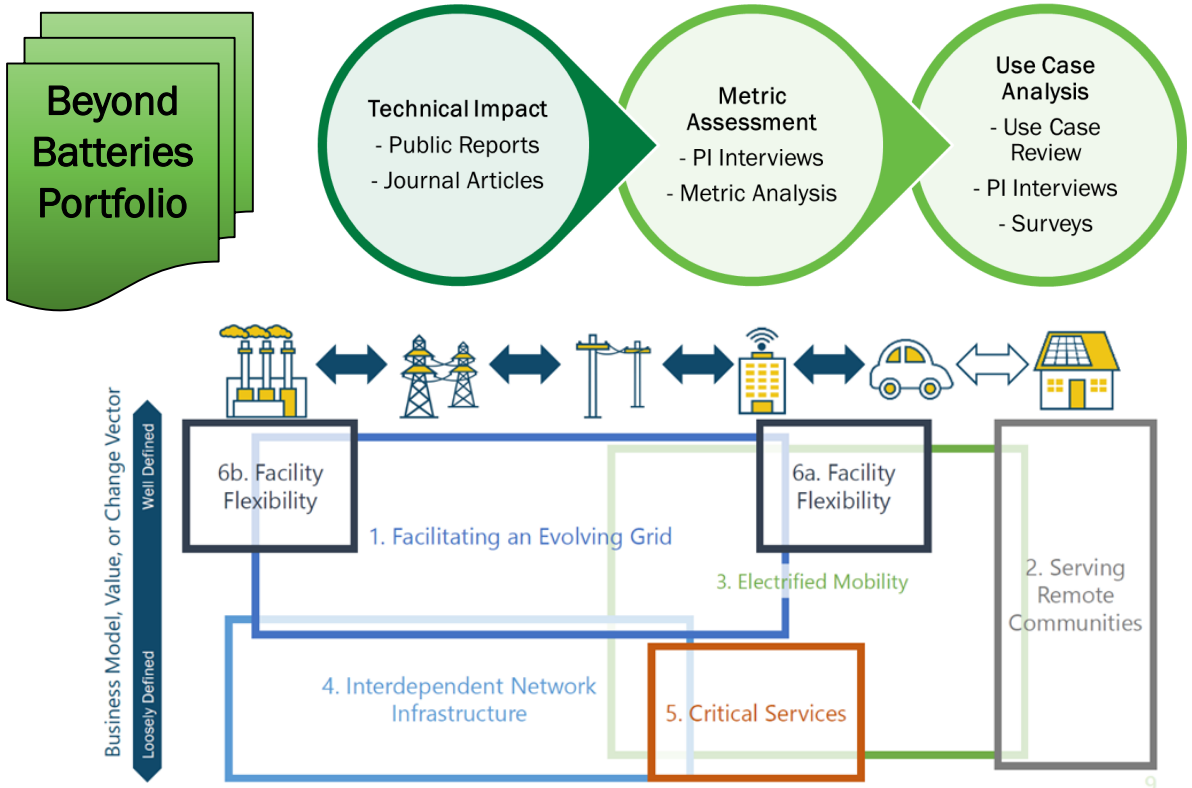
Energy Storage Capacity vs. Discharge Duration

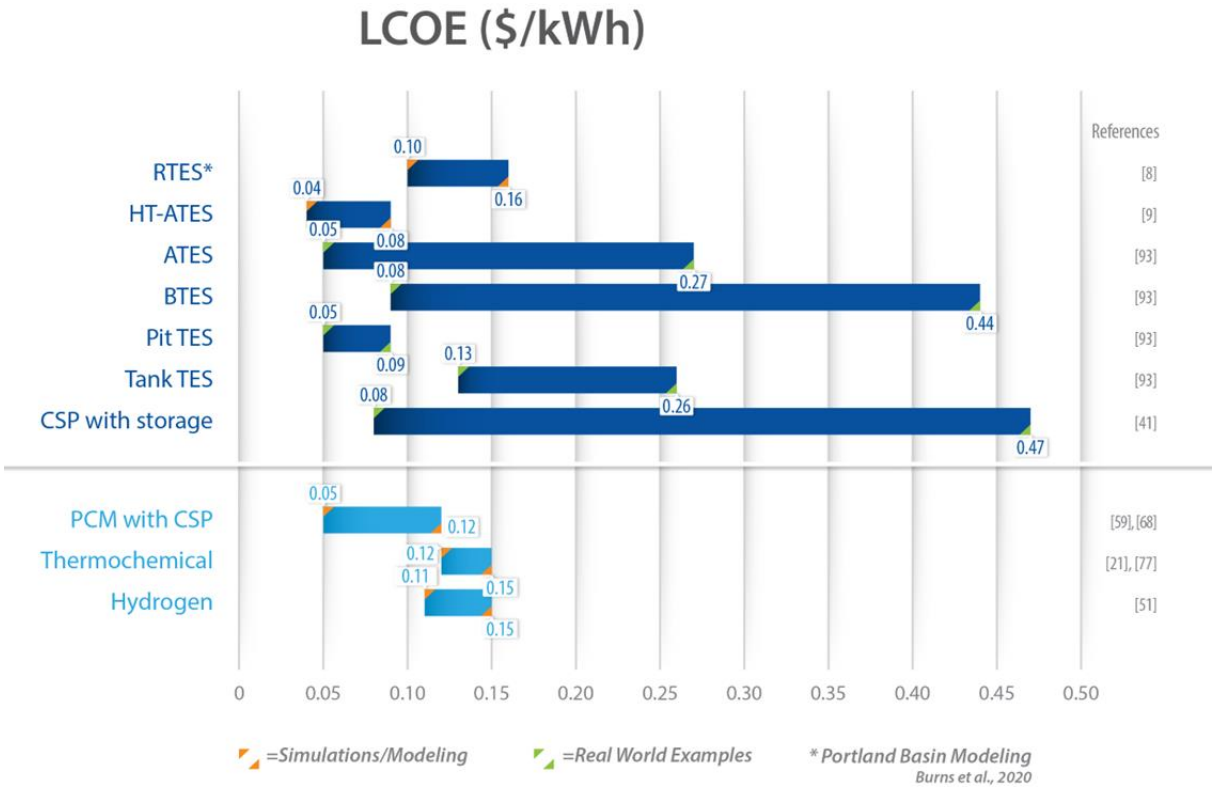


https://pubs.usgs.gov/fs/2022/3082/fs20223082.pdf

Benchmarking: Reservoir Thermal Energy Storage (RTES)

- Idaho National Lab has finalized a report that provides an overview of different thermal energy storage technologies as well as benchmarking our Beyond Batteries portfolio against the Energy Storage Grand Challenge Roadmap.
- Final report is a great resource to shed light on the potential for RTES and facilitated detailed discussions internal and external to DOE.



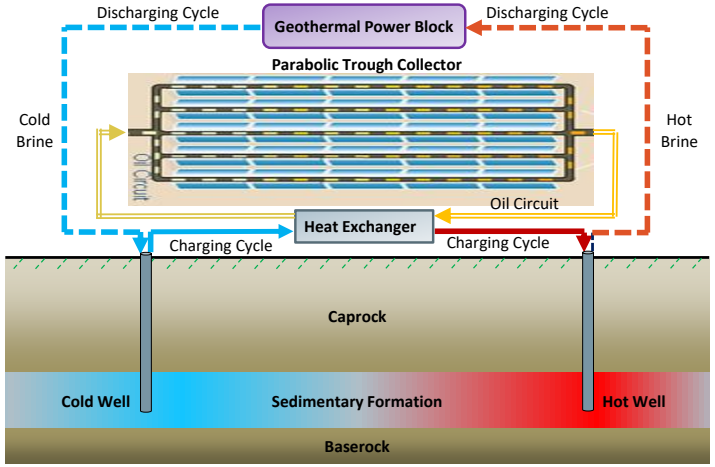


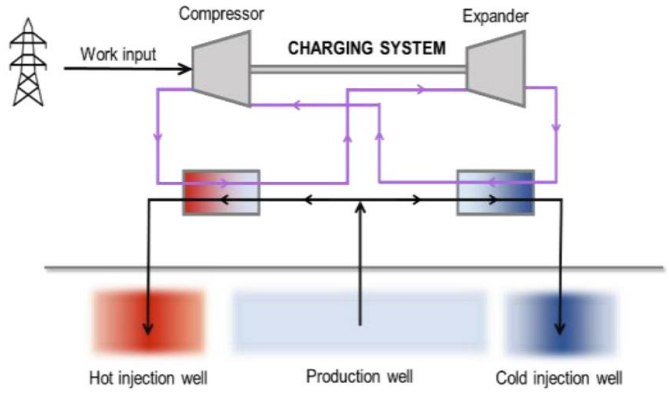
Current Work: Hybrids Research Lab Call

Objective: Identify new approaches to hybridize geothermal energy by combining high TRL technologies with the objective of near-term commercial deployment.

Three projects selected in FY23 to investigate research, analysis, and modeling of hybridized geothermal systems that include thermal energy storage:

- **National Renewable Energy Laboratory**—*Techno-economic analysis and market potential of reservoir thermal energy storage charged with solar thermal and heat pumps*
  - Evaluate the possibility of using depleted oil reservoirs for RTES and quantify cost reductions
  - Extend the capabilities of existing techno-economic models for RTES that is charged with either CSP or renewable electricity
  - Identify potential geographical locations, conduct case studies of RTES, and evaluate market potential in the US.





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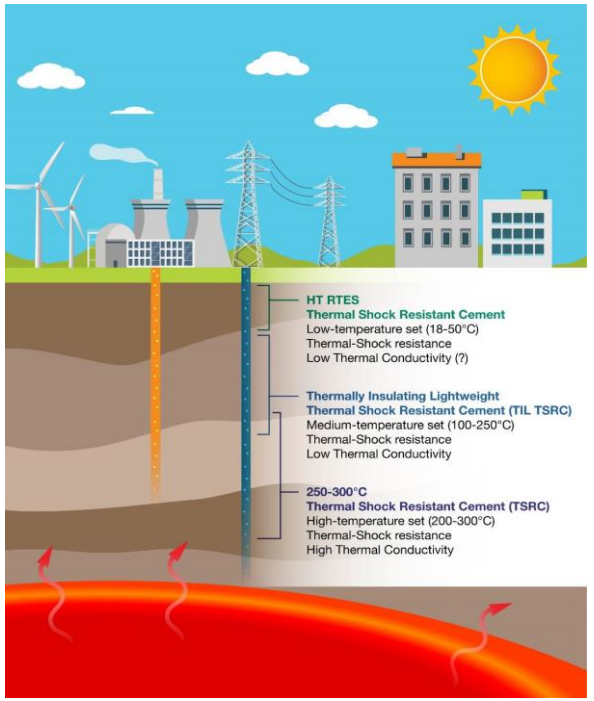
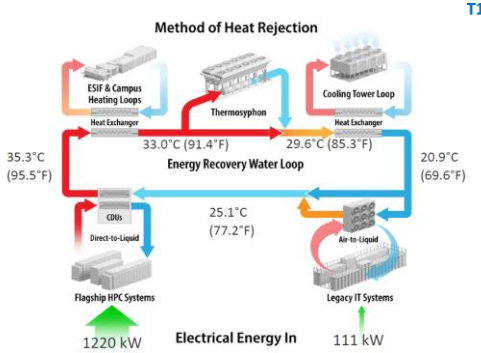
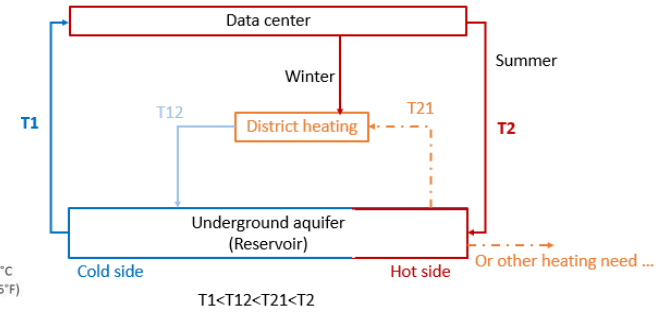
Current Work: Hybrids Research Lab Call

- **Lawrence Berkeley National Laboratory**—*Application of using unwanted thermal energy produced by data centers to be used directly in a district heating system or stored in a reservoir thermal energy storage system for later use.*
  - The project partially addressed the challenges of significant energy and water consumption in cooling information technology (IT) equipment in data centers
- **Brookhaven National Laboratory**—Cements and a modeling tool to calculate viability under various exploitation conditions of high-temperature reservoir thermal energy storage systems
  - For a robust long-term performance, the casing and cementing must be able to withstand repeated thermal stresses during injection and production of heated fluids. Currently there are no verified models to predict formation/cement/casing behavior under cyclic thermal loading.







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Recent Funding Opportunity RTES Pilot and Demonstration

Combined Wellbore Construction High Temperature Tools and Reservoir Thermal Energy Storage (RTES) - DE-FOA-0003296

Topic Area 2: Applications were accepted for the demonstration of low-temperature (<130◦ C) RTES technology for thermal storage as part of an industrial process. Within the industrial sector, low-temperature industrial heat processes (<130◦ C) make up more than 97% of the industrial heat needs in the food industry sub-sector and more than 75% in paper industry sub-sector while accounting for nearly 30% of total industrial heating CO2 emissions in 2018.Methane and CO2 emissions could be reduced by ~37% for the chemicals sub-sector by replacing natural gas with clean low-temperature heating technologies.

A successful demonstration will provide one of the first domestic opportunities to evaluate RTES technology at scale and establish a baseline for cost effectiveness and decarbonization.

Goals/Objectives:

- Store fluid in a subsurface reservoir;
- Use stored fluid in the subsurface to provide heat for an industrial process requiring less than < 130◦ C;
- Target reservoir formations below aquifer systems used for potable water in an area;
- Provide a minimum of 10 hours of thermal storage

Thank You!

the drill down

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Appendix

Low-Temperature Geothermal Overview

Geothermal Heat Pumps

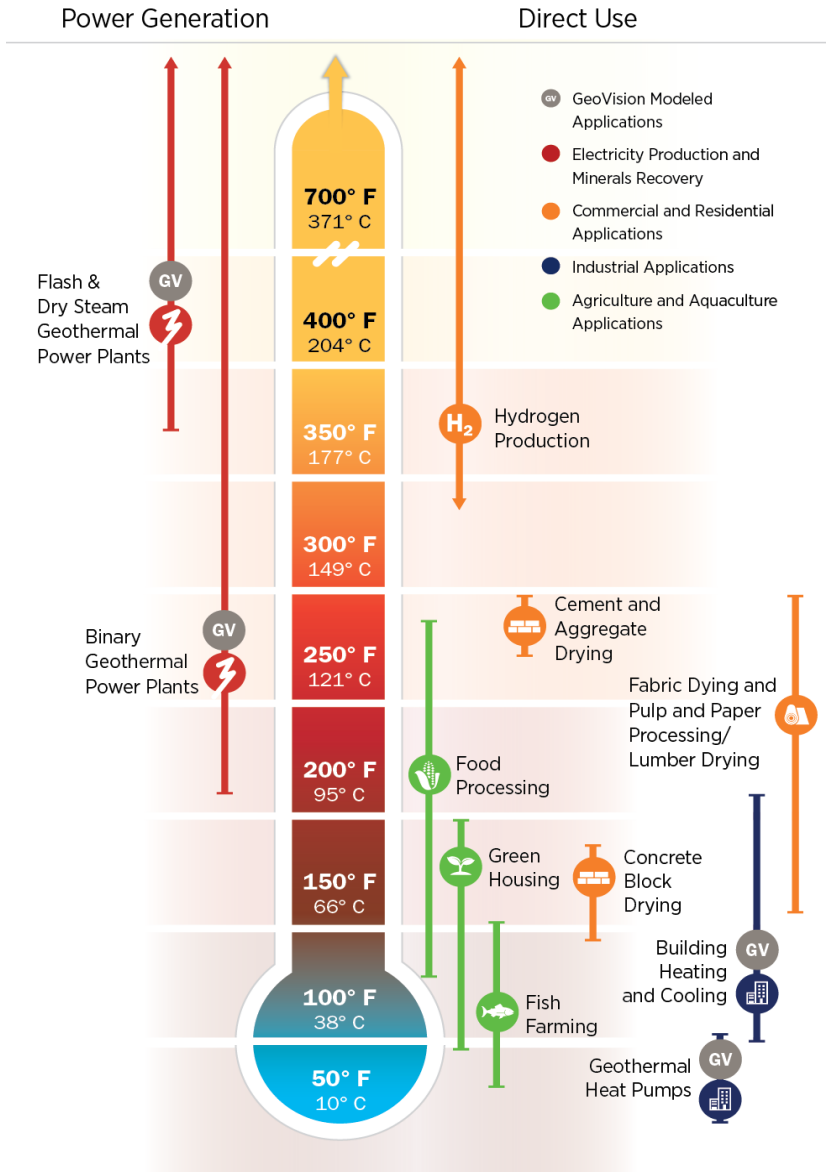
- Entering Water Temp (40–80°F)
- Shallow trenches to wells hundreds of feet deep
- Residential, light commercial

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



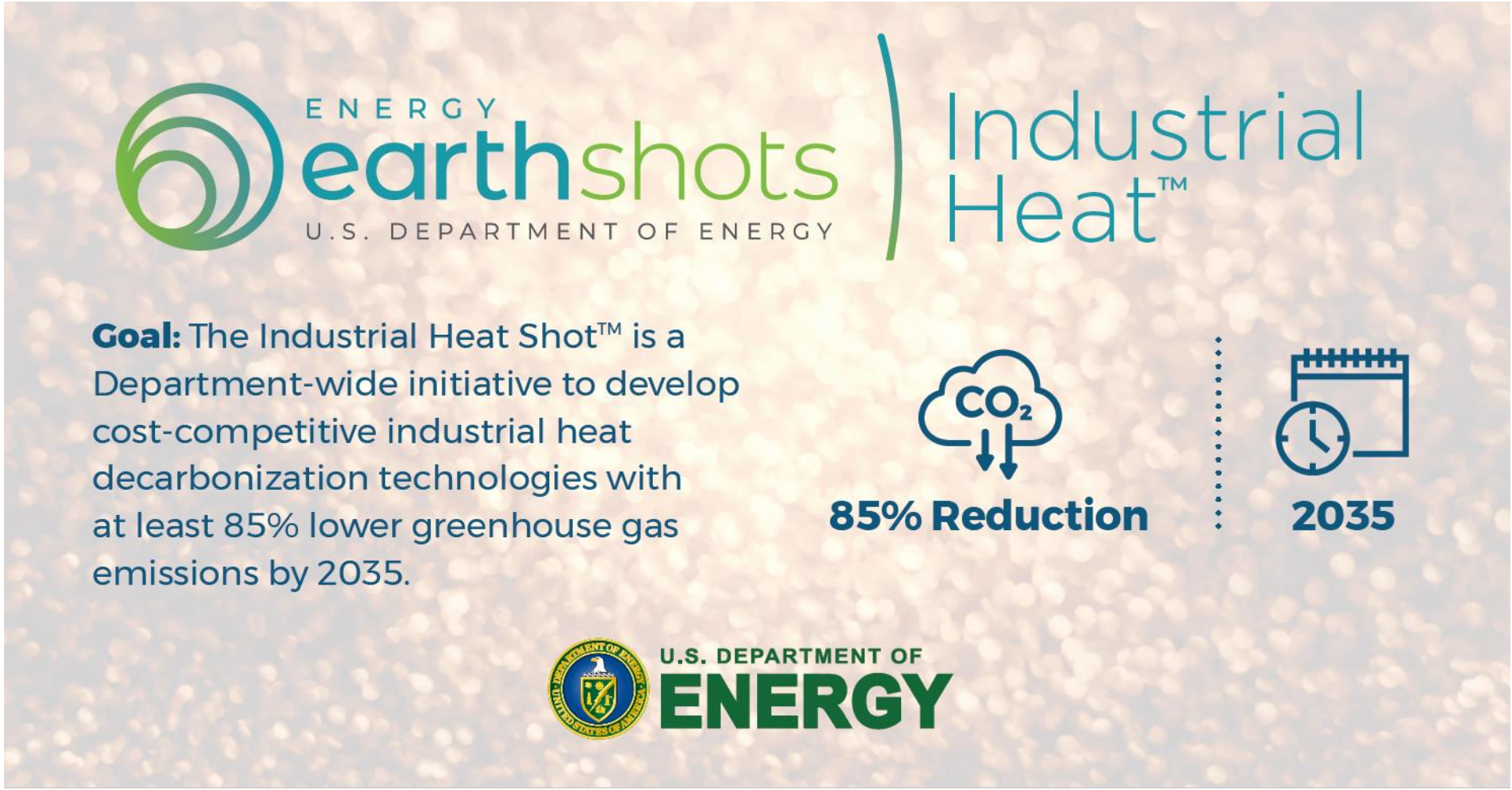
Recent Work: Reservoir Thermal Energy Storage (RTES)

Project Name	National Lab	Key Results
Advanced Thermal Shock-Resistant Cement (TSRC) Suitable to Withstand Frequent Thermal Cycling	Brookhaven National Laboratory (BNL)	Advanced performance of TSRC cements, decreased thermal conductivity, improved compressive strength, toughness, and water repellency for additional blended formulations; minimal damage at 200°C for 180 days
Dynamic Earth Energy Storage: Terawatt-Year, Grid-Scale Energy Storage using Planet Earth as a Thermal Battery	Idaho National Laboratory (INL)	Various RTES models were produced and analyzed for operational, geochemical, and mechanical issues; Decreased grid frequency variations, increase in ramping capacity, increased grid stability is modeled.
Geo-Solar Hybrid Power Plant with Subsurface Thermal Energy Storage to Increase Geothermal Plant Dispatchability	Idaho National Laboratory (INL)	Through modeling, it was determined that a dual steam flash binary plant operating in a 5-spot well pattern is the best RTES scenario; RTES offers comparable LCOE to other conventional storage options
Analysis of Curtailment of Geothermal Power Generation in the California Electricity Market and Beyond – Temporal Variability and Future Trends	Lawrence Berkeley National Laboratory (LBNL)	The Geysers curtailments range from days to weeks and up to 300 MW; Models show potential increases in energy value of 2-4 $/MWh and energy sales revenue upwards of 10%
Exploring the Role of Geothermal in Enhancing Cold-Climate Net Zero Communities	National Renewable Energy Laboratory (NREL)	Models generated using varying community sizes; LCOE is favorable for geothermal with increased community sizes but less so with smaller communities compared to residential and community PV
Alternative Compressed Air Energy Storage Technology Using Depleted Unconventional Gas Wells and Subsurface Thermal Energy Storage	National Renewable Energy Laboratory (NREL)	Models were generated that indicate potential generation from 100-1000 kWe; Sensitivity analyses conducted indicate wide range of operational permeability; Efficiencies estimated at 40-70% and LCOEs of $0.07-$0.27/kWh
A Mobile Sorption-Based Thermal Battery for Harvesting Geothermal Energy	Oak Ridge National Laboratory (ORNL)	Technology tested to use geothermal heat to charge sorption battery. Energy storage densities of 903 kJ/kg after 40 min of charging and 0.95 kW of energy discharged in 16 min. Operations can be optimized to 1.31 kW.
Novel Heat Pump Integrated Underground Thermal Energy Storage for Shaping Electric Demand of Buildings	Oak Ridge National Laboratory (ORNL)	Technology developed, tested, and modeled to reduce electric demands of buildings. Reached total usage reductions of 11% when compared to conventional HVAC system.

Current Work: Geothermica Projects w/Thermal Energy Storage

Project Name	VESTA	FLXenabler	DEMO FTES	THE CHANGE
Lead U.S. Laboratory	Lawrence Berkeley National Lab (LBNL)	National Renewable Energy Lab (NREL)	Pacific Northwest National Lab (PNNL)	Oak Ridge National Lab (ORNL)
Project Goals	Conduct detailed scientific and technical examination of underground geologic reservoirs for seasonal energy storage systems with goal of making such thermal energy storage systems commercially and technically viable Use demonstration projects underway in Europe as a testbed to evaluate technical and non-technical barriers and improve process understanding	Develop an implementable framework for flexible, fossil-free heating and cooling supply Demonstrate the impact of sector coupling and integration of heat pumps, geothermal resources, and thermal energy storage Address flexibility utilization in decarbonized heating and cooling systems at national, district and community level	Validate fracture thermal energy storage (FTES), a method of seasonal, underground thermal energy storage where an efficient heat exchanger connecting multiple wells is created using hydraulic fractures Measure the thermal efficiency and capacity of FTES at the laboratory scale and in a 10 m scale multi-month field test	Demonstrate 5th-generation geothermal district heating and cooling (Geo5GDHC) systems that can decarbonize heating and cooling in urban areas by optimizing building systems, re-using waste heat within buildings, and coupling with underground thermal energy storage Develop new models, design algorithms, and design tools to facilitate rapid design of resource-efficient and sustainable distribution systems that take advantage of sector-coupling and incorporate thermal energy storage

Department of Energy Industrial Heat Shot



energy.gov/eere/industrial-heat-shot

Department of Energy Industrial Heat Shot