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Synthetic Geothermal Reservoir Unlocking the Earth as an Infinite Battery

Emilie N. Gentry, Joseph Batir, Kevin Kitz and Hamed Soroush

1048 Arbor Trace NE, Brookhaven, GA 30319, USA

emilie.gentry@petrolern.com

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ABSTRACT

As an alternative to traditional geothermal energy production, this research evaluates the feasibility of utilizing a Synthetic Geothermal Reservoir (SGR) to store the abundant alternative energy resources such as solar, wind, nuclear, and industrial waste heat as thermal energy in the subsurface, and then to recover that heat as a 24/365 dispatchable geothermal reservoir for power or industrial heat. SGRs use the subsurface as a medium for thermal energy storage collected from various renewable sources such as wind energy or concentrated solar power to reliably produce on-demand industrial heat and electrical power, using the recovered heat. In this way, SGRs can provide weather-independent, renewable, baseload energy, without the traditional geothermal geographic constraints of initially hot rock. Instead, the hot geothermal reservoir is engineered by deploying petroleum workforce and other energy resources such as wind or solar. Results suggest SGR can turn off-peak power generation into baseload geothermal industrial heat or power, which can provide a unique way to “Drill to a Green Energy Future”.

In the many sedimentary basins located around the globe, a technically producible geothermal resource will exist if there is sufficient sedimentary thickness. These resources are often low enthalpy that would be best suited for direct use applications. Organic Rankine Cycles may be able to generate electricity in some of these areas if there are sufficient water production rates. However, this is considered a niche power potential market as often the resource temperatures or fluid production are major limitations to profitable project. Here, we focus on the renewable energy penetration potential across different markets using SGR instead of traditional geothermal energy production.

In this paper, we summarize current energy storage technologies and emerging technologies such as SGR. We will include a complete review of the work that has been completed on subsurface energy storage related to SGR. This study presents documented locations ideal for an SGR pilot project in Wyoming, in addition to high-level examinations of other markets with existing renewable energy curtailment. Successful SGR deployment will increase renewable energy penetration, which could then attract additional funding and investment driven by a clean energy grid.

1. INTRODUCTION

As renewable energy sources are incorporated into the power grid more, the demand and market value for energy storage has become an increasingly high and is growing quickly to account for the intermittent nature of these energy sources and create stable and reliable operations of the power system network. IRENA estimates a global need of 150 GW of battery storage by 2030 with the global energy storage market value is $7.81 billion. Current technologies for average large-scale batteries offer limited power capacity, energy storage, and duration. These limitations make it difficult to meet the global demand that IRENA predicts. One way to rapidly scale energy storage to fulfill the demand is through a Synthetic Geothermal Reservoir (SGR) which produces a significantly higher power capacity, energy storage, ad longer duration than a typical battery. It would take multiple average large-scale batteries to meet the same parameters as a single SGR unit.

We have analyzed the market potential for the SGR concept (Figure 1), also known as Geo-TES, RTES, and “geothermal battery”. Based on numerous national lab and university studies examining various technologies we believe widespread commercial deployment opportunities for SGR exist that can provide weather independent, renewable, baseload energy, without the traditional geothermal geographic constraints of initially hot rock (Wendt et al., 2019; Sharan et al., 2020). Instead, the hot geothermal reservoir is engineered by deploying the petroleum workforce and complementary underutilized renewable energy resources. The SGR can turn off-peak intermittent renewable energy generation into baseload geothermal power.

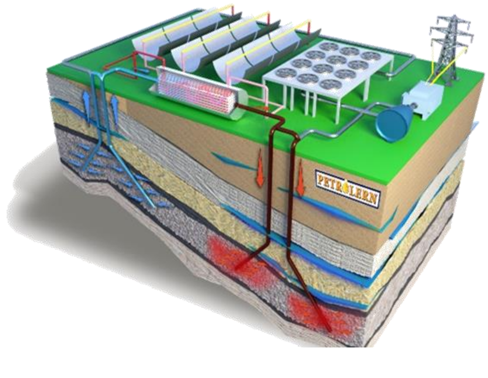

Figure 1. Schematic of a Synthetic Geothermal Reservoir system.

The following sections review current energy storage technologies and outline how SGR fills major gaps in energy storage technology.

2. CURRENT ENERGY STORAGE TECHNOLOGIES

With increased renewable energy integration in power grids, the demand for energy storage systems has become increasingly necessary to assist with the efficiency and reliability of the power generated from intermittent renewable resources like wind and solar. An energy storage system converts energy or electricity to a form that can be reserved in a storage medium and then converted back to electricity when demand is high. In this way, these storage systems offer a flexible method to conserve excess energy when demand is low and discharge energy when demand is high.

This section aims to provide a comprehensive review of state-of-the-art utility-scale energy storage technologies.

2.1 Mechanical storage

Mechanical storage systems use heat, water, or air with machinery like compressors or turbines to store inputted energy. While the physics of mechanical energy storage systems are usually simple, the technologies that are used to enable the storage and use of mechanical energy are complex. Generally, mechanical storage has an installed capacity of about 166 GW. There are three main mechanical energy storage types: pumped hydro, compressed air, and flywheel.

Pumped hydro storage is one of the most commercially developed mechanical storage systems. Currently, these types of systems take up about 94% of the world's energy storage capacity (Rahman et al., 2020). These systems have a capacity about 100 to 2000 MW and have a long discharge duration and cycle life. The round-trip energy efficiency of these systems varies between 70-80%. The main limitation of these systems is the nature of the site required, needing both water availability and elevation differences.

Compressed air energy storage stores compressed air or another gas under pressure in an underground cavern or container. When electricity generation is needed, the pressurized air is heated and expands in an expansion turbine driving a generator. There are multiple global examples of this type of storage that have capacities ranging from 66 kW to 290 MW with power-to-power efficiencies between 42-70%.

Flywheel energy storage systems (Figure 2) use electrical energy input that is stored in the form of kinetic energy from a spinning rotor. These systems are used in frequency regulation and hybrid energy systems where renewable energy is integrated. Some of the key advantages of flywheel energy storage is that is has a long life and an 80-90% efficiency rate. The installed capacity of a flywheel energy storage system is 931 MW (Rahman et al., 2020).

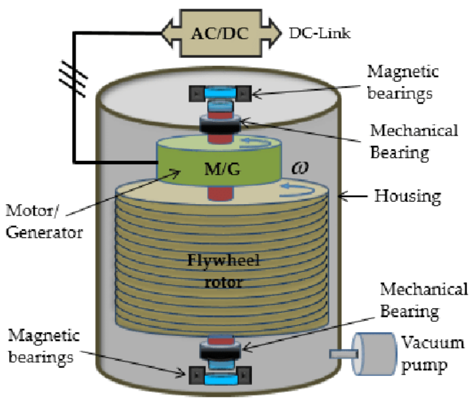

Figure 2. Schematic of flywheel energy storage system from Amiryar & Pullen, 2020.

2.2 Electro-chemical storage

Electro-chemical battery storage systems claim some of the highest installed capacities of energy storage (Rahman et al., 2020). The most common utility-scale electro-chemical batteries are lead-acid, lithium-ion, sodium-sulfur, nickel–cadmium, and flow batteries.

Among electro-chemical battery technologies, Li-ion have the highest market share and dominate the energy storage market as they provide a high efficiency, longer life cycle, and high power and energy density. The biggest challenge with Li-ion batteries are that they have a high capital cost which inhibits the success for it to be a commercial-scale energy storage solution. Pb-A batteries are often used for micro-grids, hybrid systems, and bulk energy storage. Although Pb-A batteries are highly efficient and lower capital cost, the main challenges of these batteries are the short lifetime and intensive maintenance requirement. Na-S batteries have high energy density, longer lifetime, and very little maintenance which makes it an attractive technology for large commercial use. Ni-Cd batteries provide high energy density and require low maintenance but disposing of the toxic metals is a major challenge.

A flow battery uses electrolytes through electrochemical cells that store energy. The advantage here is that the power and energy rating design are separate, making them suitable for power- and energy-related applications. The flow battery system is often used for electric energy time-shift and resiliency. The largest flow batter has a power capacity of 25MW and an energy capacity f 100 MWh. It can discharge energy for up to 10 hours.

2.3 Thermal storage

Thermal energy storage (TES) has the second highest installed capacity for energy storage at 3.21 GW. The most common application for thermal energy storage is in solar thermal systems. TES has a lot of potential, but the current technology growth is inhibited by intermittency solar insolation capacity. Thermal energy storage store energy in the form of heat until it is ready to be used when there is high demand. This technology is commonly used to aid in energy shifting, peak shaving, and electric bill management. Thermal energy systems are classified into sensible heat, latent heat and thermochemical storage based on the thermal mechanism used to store energy. Sensible storage occurs when the temperature of a material is raised or lowered, whereas latent storage happened when there is a phase change of a material without a change in temperature. Thermo-chemical storage occurs with a chemical reaction or sorption process that takes place on the surface of a material. Each of these energy storage systems has unique characteristics of efficiency, specific energy, cycle duration, and self-discharge. It is these properties that determine how suitable a particular storage system is for various purposes.

Underground thermal energy storage (UTES) is used for seasonal storage of large amounts of thermal energy in subsurface spaces. These systems supply process cooling, space cooling, and space heating (SITE). UTES systems are divided into two main methods of thermal energy storage systems: Aquifer thermal energy storage (ATES) and borehole thermal energy storage (BTES).

2.3.1 Aquifer Thermal Energy Storage

ATES systems utilize natural water in a saturated and permeable later in the subsurface as the storage medium for heat. The transfer of thermal energy is carried out by an open system in which groundwater is extracted from the aquifer and reinjected at a modified temperature into the ground using separate wells to carry thermal energy into and out of the aquifer. These systems utilize low-temperature geothermal resources and are generally used for direct use applications for heating a cooling. ATES systems require an underground, water-yielding geological formation that is either unconsolidated or consolidated (Lee, 2010). This involves drilling at least two hydraulically-coupled wells to circulate water between the storage reservoir and the energy system and water supply. Here, the pair of wells are pumped constantly in one direction or alternatively from one well to the other (Figure 3) This allows for energy storage while providing heating and cooling on a seasonal basis. To meet large cooling and heating demands, the aquifers can be discharged effectively through multiple productions wells (Lee, 2010).

Figure 1. Basic operational regimes for aquifer thermal energy storage (a) continuous regime. (b) cyclic regime. (after Nielsen [3].)

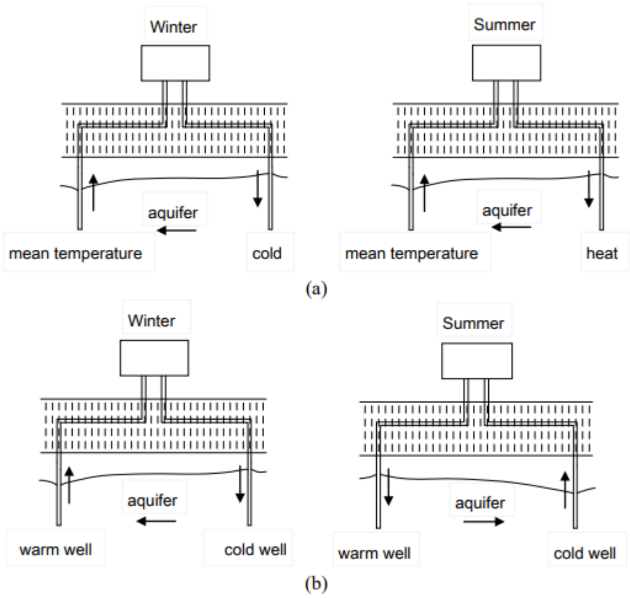

Figure 3. Basic operational regimes for aquifer thermal energy storage. (a) Continuous regime and (b) Cyclic regime after Nielsen (2003).

The advantage of ATES systems is that there is a higher heat transfer capacity in wells compared to a borehole. In this way, ATES has the potential to offer an economical way to store thermal energy for long periods of time. These systems have been successfully installed around the world for seasonal heating and cooling. With global goals to reduce greenhouse gas emissions, increase the use of sustainable energy, and improve energy efficiency, ATES systems contribute to these goals significantly as about 40% of global energy consumption is for heating and cooling.

An essential part of developing an ATES system is to evaluate the subsurface conditions to understand the technical and economic feasibility. This includes a site investigation that helps gain more knowledge of the aquifer properties to provide a better basis for design. Some of the important parameters for an ATES system include high porosity, medium to high hydraulic transmission rate around the boreholes with a minimum of ground water flow through the reservoir, and ground water chemistry (Lee, 2010; Dickinson et al., 2009). Based on the results of the site investigation, a conceptual model is created, and the hydraulic properties of the aquifer and associated rock layers are derived. This model is used to create the final design of the system using simulation models. It is important to understand the loading conditions of heat and cold and the supply and return temperatures in order to accurately calculate the flow rates and sizes of the ATES system (Dickinson et al., 2009).

The thermal behavior and lifetime of the storage system is dependent on the direction and velocity of the groundwater flow, which is determined by the regional pressure gradient (Lee, 2010). Hydro-thermal modeling of the system is valuable for determining the sensitivity of various reservoir parameters necessary to predict system performance. ATES systems are highly efficient and offer major environmental benefits from large savings on fossil fuel and electricity. The market for ATES has substantial profit expectations in favor of further growth for large-scale applications (Dickinson et al., 2009).

These storage systems are great for large-scale applications due to their high storage capacities. Typical use cases of ATES systems include the heating and cooling supply of office buildings, hospitals, airports or universities and have been deployed for district heating networks (Dickinson et al., 2009). The first ATES system was developed in Shanghai, China around 1960 where large amounts of groundwater were used to provide cooling to textile factories (Fleuchaus et al., 2018; Paksoy, 2007). This process resulted in land subsidence. To counter the subsidence, cold surface water was reinjected into the aquifer, and it was found that the stored water remained cold after injection and could be used for industrial cooling. In the 1970s, ATES systems were further studies in other countries (Tsang et al., 1980). Today, there are more than 2800 ATED systems in operation (Fleuchaus et al., 2018). Sweden and the Netherlands dominate the market in terms of implementation (Paksoy, 2007). The Malmo IKEA storage in Sweden implements five warm wells and six cold wells to supply a maximum heat demand of 1300 kWth and a yearly energy supply of 2350 MWth. The maximum cold demand is 1300 kW and an energy supply of 1450 MWth/yr (Urchueguia, 2016). In 2012, there was approximately 104 ATES systems in Sweden with a total capacity of 110MW and 2740 systems in the Netherlands with a total estimated capacity of 1103 MW (Anderson et al., 2013; CBS, 2012). Besides the Netherlands and Sweden, Belgium, Turkey, Germany, and Japan are increasing the application of ATES (Bloemendal et al., 2015).

2.3.2 Borehole Thermal Energy Storage

A borehole thermal energy storage (BTES) system also uses the subsurface as a storage medium for heat but is a closed-loop system that requires a series of multiple geothermal wells (Figure 4). Here, BTES systems circulate a fluid through a borehole system in dry rock. An aquifer is not needed for this type of system. The design of BTES systems depends on the project context and are developed on the basis of numerical simulations (Lanini et al., 2014). Systems of all sizes have been built. Like ATES, BTES also provides season and short-to-medium term storage that can be used for heating and cooling.

The upper temperature limit for a BTES to store is 85°C due to the characteristics of the pipes used. Most systems do not approach this temperature (Lanini et al., 2014). Boreholes have a lifetime in excess of 100 years. To provide good thermal contact with the surrounding rock, the borehole is usually filled with a highly thermal conductive grouting material or water depending on the geological conditions. The challenges with BTES systems are that they are often more costly

Numerous sites already exist in Canada and central and northern Europe where they provide district heating often with the aid of a heat exchanger. In Sweden, the Anneberg BTES system combines 100 boreholes inter-linked by series connections (Lanini et al., 2014). The Drake Landing Solar Community BTES project in Okotoks, Canada was designed with a radial flow pattern of 144 boreholes each 35 m deep (Lanini et al., 2014). To provide high quality air conditioning of the Minhang archives building in Shanghai, a ground source heat pump system is used with 280 vertical boreholes with single U-tubes and parallel connections (Lanini et al., 2014).

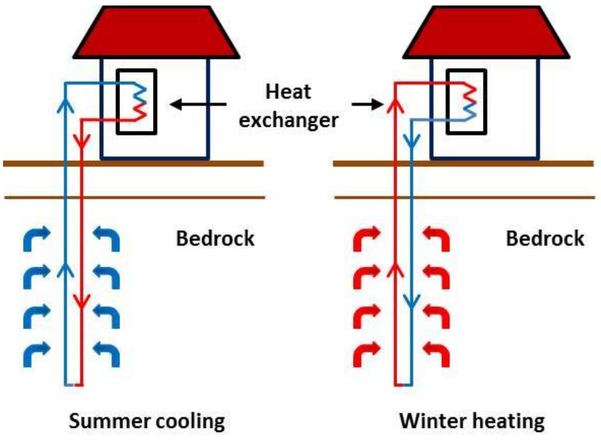

Figure 4. Schematic of seasonal borehole thermal energy storage systems after Nordell (2007).

Both ATES and BTES systems are innovative ways to use the subsurface to store heat energy to later use as heating and cooling for buildings and homes.

3. SYNTHETIC GEOTHERMAL RESERVOIR

An alternative method for underground thermal energy storage uses the subsurface to store heat produced from alternative energy sources and produce geothermal energy upon discharge. The SGR concept (Figure 5), also known as Geo-TES and "geothermal battery", allows for electricity to be produced from thermal energy storage unlike ATES and BTES systems. Based on numerous national lab and university studies on SGR, and more generally on thermal energy storage and EGS, widespread commercial deployment opportunities for SGR exist that can provide weather-independent, renewable, baseload energy, without the traditional geothermal geographic constraints of initially hot rock (Wendt et al., 2019; Sharan et al., 2020). Instead, the hot geothermal reservoir is engineered by deploying the petroleum workforce and renewable energy resources. The SGR can turn off-peak intermittent renewable energy generation into baseload geothermal power through the SGR.

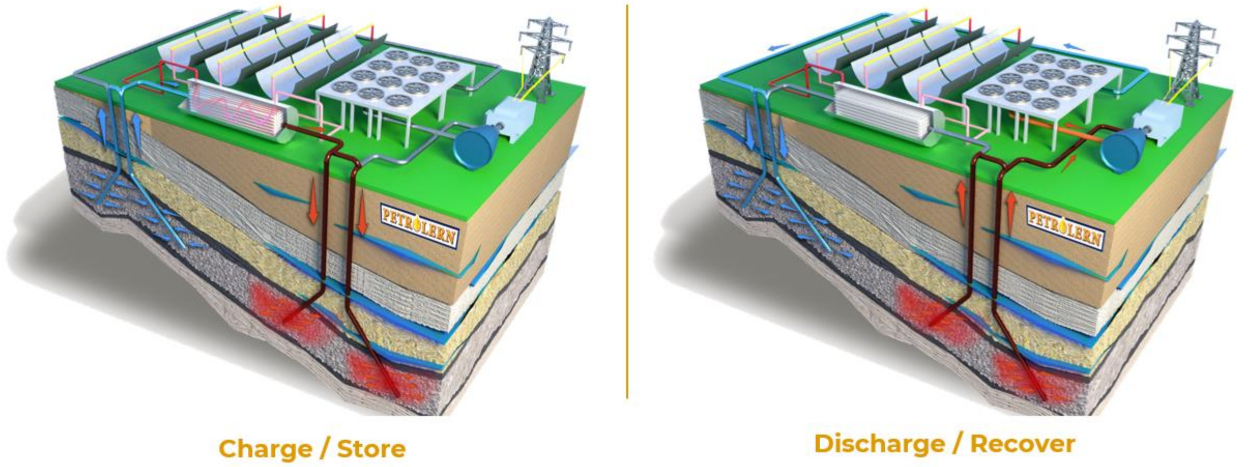

Figure 5. Synthetic Geothermal Reservoir diagram. (Left) The SGR charge cycle heats cold water from the reservoir using renewable energy and stores the heat in the subsurface. (Right) The SGR discharge uses the stored heat, produced as hot water or steam, and then reinjects the now cooled water back into the reservoir.

During charging, cool water is pumped out of half the wells (cool wells), which is heated with the LCES, and injected into the hot wells. The permeable sandstone formation provides efficient heat transfer to/from the fluid and dense energy storage capacity. In the discharge cycle, hot water and steam flow out of the hot wells, through a dry-cooled geothermal power plant. All of the produced water is sent back to the cold wells. The hot well array can accept two to four times the energy flow needed by the power plant. Example, a 100MWe geothermal plant needs 400MWth. The hot wells can be charged with 800 to 1600MWth continuously. This huge capacity provides both short and long-term storage.

In most locations around the world, commercial geothermal temperatures and flow rates are difficult to locate in sufficient quantities needed for geothermal power and/or useful heat production. Alternatively, the category of Enhanced Geothermal System (EGS) broadly includes any reservoir requiring intervention to increase technical and economic viability of a resource, including, but not limited to stimulated hot rock, "closed-loop" geothermal (CLG), Synthetic Geothermal Reservoir (SGR), and others. Further compared to ATES and BTES technologies which also use the subsurface to store energy, SGR can produce electricity for the grid from geothermal power production. Instead, the hot geothermal reservoir is engineered by deploying the petroleum workforce and solar energy resources. The SGR can turn off-peak intermittent renewable energy generation into baseload geothermal power through the SGR.

Depleted oil and gas reservoirs are an ideal location for SGR and hybrid geothermal power plants. SGR systems provide an alternative opportunity that leverages the existing subsurface knowledge and energy infrastructure to utilize low carbon power while performing similar field operations. SGRs use the subsurface as a medium for the storage of heat generated using renewable energy to reliably produce on-demand electrical power using the recovered heat. Here, SGR provides high temperature seasonal and diurnal storage of heat from two low-CO_2 energy sources: solar thermal and/or excess low-CO_2 grid power (e.g., PV, wind, nuclear, hydro). The concept utilizes multiple wells drilled into an identified high-permeability zone, which provides an opportunity to repurpose existing oilfield infrastructure in sedimentary basins including wells, pipelines, transmission lines, and more. Initial ground temperature is irrelevant. Hot water created from a combination of renewable energy is injected into the subsurface to be stored and produced later during high electricity demands.

The value proposition of SGR deployment includes producing cost-effective renewable electric generation (or heat) at industrial scale as a zero-carbon baseload power supply. SGR deployment utilizes existing oil and gas technology that is commercially mature, but the combination of these technologies to develop an SGR system has not been done to date. Based on previous modeling, power generation cost estimates for SGR electricity are $80 – 125 / MWh. As a fully dispatchable renewable energy, SGR provides a stable and reliable capacity and reduces the grid need for batteries (Sharan et al., 2021).

One of the main challenges of SGR systems are the geochemistry challenges associated with hydrothermal waters in the wellbores. Recent research lead by Lawrence Berkely National Laboratory and Idaho National Laboratory investigated the geochemistry of SGR systems (Spycher et al., 2021). It was noted that the precipitation of retrograde solubility minerals upon heating which seriously impacts the system operations if careful attention is not given in the system design phase. Most failed ATES systems to date are caused by mineral scaling issues, which would suggest higher temperature SGR systems would have more trouble. However, numerical modeling shows that not all saline aquifers exhibit the same elevated potential for mineral scaling. It is understood that the precipitation of retrograde solubility minerals such as calcite and anhydrite were dependent on the brine chemistry sulfate content rather than the salinity (Spycher et al., 2021). The risk of detrimental scaling can be reduced by integrating analysis of the brines and rock formation geochemistry (water-rock interaction) with the investigation of the thermal and hydrological parameters that are often conducted. Therefore, scaling mitigation measures will play a major role in the viability and long-term operation of SGR systems.

As the world's demand for alternative carbon-free energy that is reliable increases, energy storage becomes an essential requirement for the expansion of renewable energy. SGR provides an energy storage solution that is long-term, dependable, and resilient. Not only does SGR turn alternative energy sources into baseload energy through geothermal power production, but it also provides a long-term solution that produces heat or electricity. Every component of the technology used for SGR has been proven and is utilized by the energy industry. SGR integrates existing, proven technologies in a new innovative way.

4. IDEAL LOCATIONS FOR SGR

Current models suggest SGR can be deployed in any location with high permeability (~100 md) and high porosity (12 – 25 %) rock. This type of reservoir is often abundant in sedimentary basins and is not a major limitation of the technology. Aquifers can provide an excellent location to utilize SGR technology since these are highly permeable and porous zones with a source of fluid needed for the technology. To maintain thermal storage, the optimal depth for the reservoir is about 900-1500 m deep and about 100 m thick. Sedimentary basins with aquifers co-located with high wind or solar resource are ideal locations where renewable energy sources require energy storage.

Wyoming is an epicenter of various energy types. The wind resource in Wyoming is some of the highest in the country and provides a great opportunity to generate renewable energy but wind energy lacks dependability as it is intermittent. There are pervasive aquifers within all major sedimentary basins in Wyoming (Figure 6), co-located with high wind resource that could be the renewable energy source requiring energy storage. Areas of dark blue have exceptionally high wind speeds for the United States and therefore have excellent wind power production potential. The coincidence of these dark blue regions with aquifer outlines indicates areas ideal for SGR technology deployment. For SGR to be effective, it is necessary to be near transmission lines to add the generated power to the grid. The yellow lines represent transmission lines.

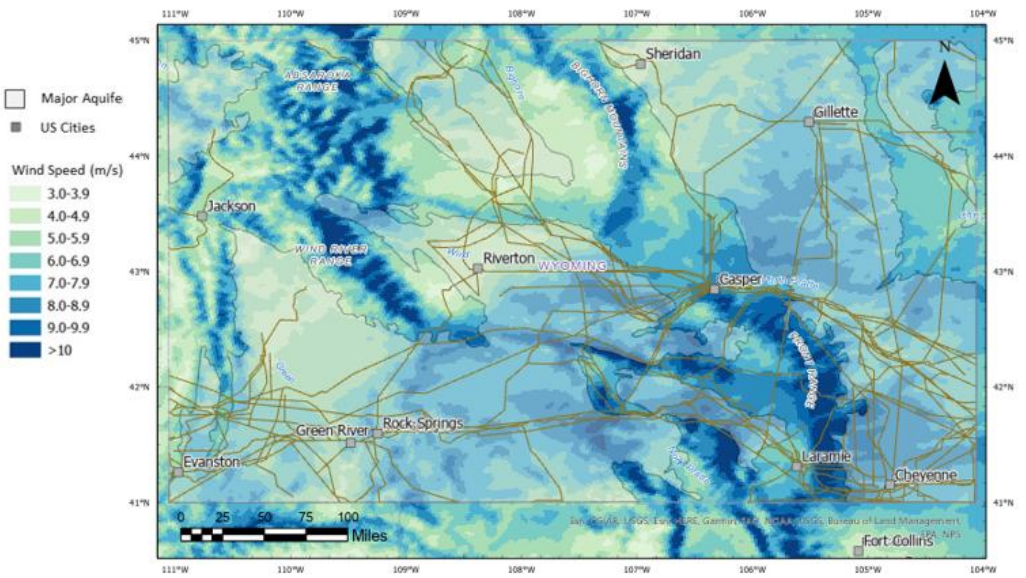

Figure 6. Map displaying co-located aquifers and wind resource in Wyoming for SGR

A more detailed look at potential sites for SGR in Wyoming suggests that the Fort Union Aquifer in the northeast part of the state is co-located with high wind resource, is not a source for drinking water, and is surrounded by transmission lines (Figure 7). The Fort Union Group is composed of interbedded claystone, sandstone, siltstone and coal. It fulfils the high permeability and porosity requirements. The formation is about 2000-5000 ft thick and 6000-12,000 ft deep which provides sufficient thickness to be a reservoir and depth to maintain it's temperature. Given that these resources are co-located within the Powder River Basin, it is likely that abandoned oil and gas wells could be repurposed to lower development costs. Additionally, the proximity to Casper, Wyoming's largest city, provides optimal opportunity to supply energy demands nearby. These details suggest specific site locations for the success of SGR deployment which would help Wyoming create a baseload energy from the abundance of high wind resource that is not currently being used to its fullest capacity.

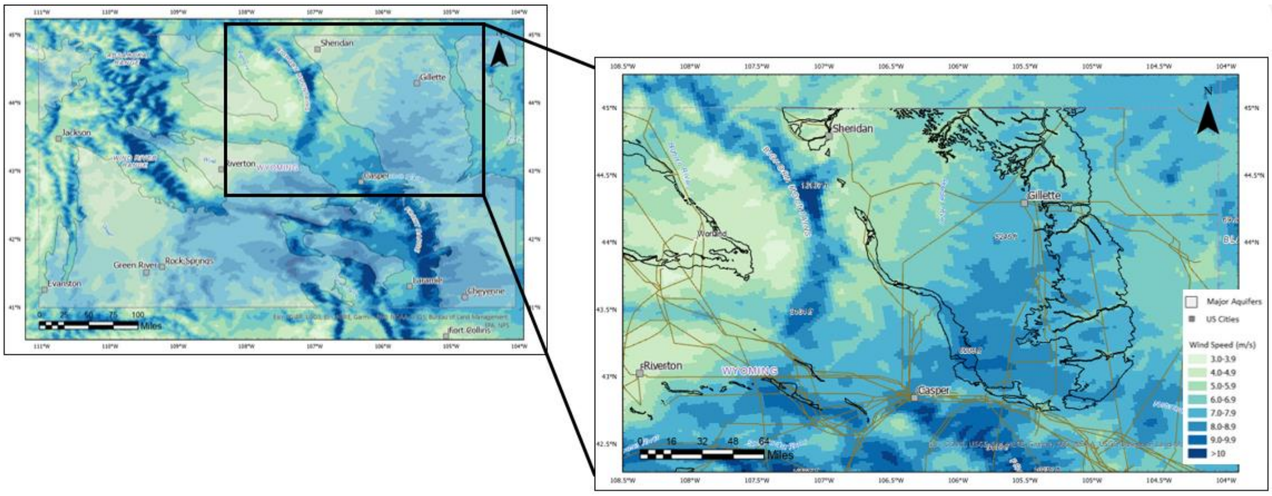

Figure 7. Zoomed in map focusing on SGR potential in the Powder River Basin.

Another prime location that is feasible for SGR deployment is Texas. There are many sedimentary basins and aquifers in the state of Texas the easily fulfill the geologic and hydrologic parameters of an SGR system. Texas has the potential to curtail both wind and solar energy for energy storage. In West Texas, Midland is known to be a center of oil and gas in the Permian Basin. The Permian Basin contains many locations where highly permeable and porous rock is co-located with widespread aquifers. The Edwards-Trinity Aquifer in the Permian Basin near Midland provides an ideal geologic setting for SGR. Midland's abundance of sunny days and large amounts of unused acreage are quickly making it an attraction for solar power generation. Here, SGR can turn off-peak solar generation into baseload geothermal power, providing Midland, an oil and gas boom town, a unique way to drill to a decarbonized energy future. The Permian Basin around Midland has thousands of well drilled each year, and almost 150,000 inactive wells currently (S&P Global). SGR provides an opportunity to repurpose abandoned wells for geothermal purposes and reduce the cost of installment. The generated electricity can be used to power oil and gas operations in the field or to provide power to the nearby cities of Midland and Odessa.

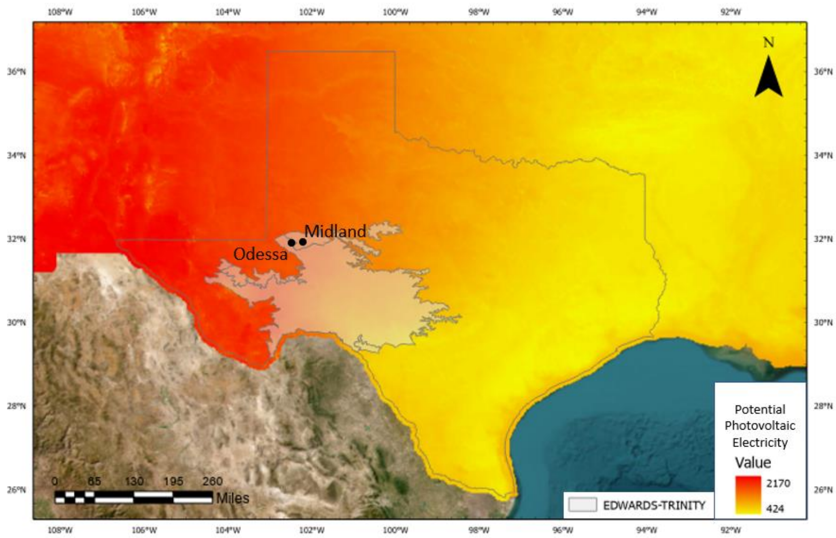

Figure 8. Map of Texas displaying potential photovoltaic electricity and the Edwards-Trinity Aquifer as potential areas for SGR.

California struggles immensely with wind and solar curtailment. The state has excellent wind and solar resource, but the resource is intermittent and does not meet needs during peak-demand. This is a massive lost opportunity for the state's energy market. Here, SGR is the ideal solution to provide the stable energy storage needed to make renewable energy sources satisfy peak-demand. California is an optimal market for SGR to generate on demand electricity generated from renewable energy. The state has sufficient wind and solar energy to be utilized as the renewable energy source. The San Joaquin and Sacramento Basins in California have been well explored and produced by the oil and gas companies. Bakersfield, California lies on the southern edge of the San Joaquin sedimentary basin where high permeability and porosity rock exists. Within the San Joaquin sedimentary basin exists the San Joaquin aquifer system that has wells as deep as 1060 m (Planert & Williams, 1995). With all of the key components needed for an SGR and an energy market that would greatly benefit from efficient energy storage, California is a key location to deploy SGR with further studies on specific areas. SGR can turn California's off-peak solar and wind resource into baseload power and sole the state's energy curtailment issues.

4. CONCLUSIONS

Storage of energy is essential to reducing the uncertainty of reliable, clean energy brought by inflexible renewable energy sources. There are several types of energy storage technologies, but these existing options fall short of providing multi-day and seasonal storage and many are not economically viable. Other limitations of existing technologies are that the technology is not tests, deployment is location limited, and the technologies are expensive and are expected to remain so for years.

This paper proposes a novel concept of Synthetic Geothermal Reservoir (SGR) with renewable energy hybridization for long-term seasonal storage. In an SGR, the hot water produced through a heat exchanged is stored in a sedimentary basin. SGR provides nationwide long-duration energy storage and geothermal power through a viable transition of core oil and gas skills and companies to green energy. This technology is more economically viable than other battery storage options and can store energy for months at a time to be delivered when needed. It is not location limited as highly permeable and porous geologic formations are geographically widely found.

Ideal locations across the United States and the world are prevalent given that the initial subsurface temperature is irrelevant. The requirements for a successful SGR system include (i) high permeability and porosity rock, (ii) fluid source such as an aquifer, (iii) renewable energy source such as wind or solar energy, and (iv) proximity to transmission lines or end user. As outlined in the paper, there are many locations where these parameters are co-located. Wyoming, Texas, and California are great examples of feasible locations for SGR deployment.

While wind and solar are low cost and critical to addressing growing clean energy demands, the capacity growth is limited by grid integration in low-demand periods. SGR can transform the energy space by turning renewable energy into baseload power through geothermal power production. This allows for further renewable energy capacity growth without curtailment. Integration of multiple proven technologies, technical expertise, and industries including drilling and subsurface energy management advances the career and energy potential for the global economy. In this way, SGR unlocks the subsurface as an infinite battery for green energy to be produced through geothermal power production globally.

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