RENEWELL

The Storage Potential of Gravity Wells

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Inactive oil and gas wells as a storage resource

As the penetration of variable renewable energy resources increases in the United States, the availability of energy storage becomes more important to maintain grid reliability. Gravity energy storage is a mechanical storage technology that accumulates and releases energy due to an object's change in height, otherwise known as vertical displacement. Pumped hydro storage is the most popular gravity storage technology yet it requires very specific geographies. This white paper explores the potential for using the massive depth and relative abundance of inactive oil and gas wells for gravity storage--thus converting them into "gravity wells"--and the feasibility of using such technology for large-scale electricity storage.

The EPA estimates the number of inactive oil and gas wells at around 3.4 million[1], approximately 2.1 million of which are "idle" -- they have not been properly plugged and abandoned[1]. These wells are scattered across the U.S. but the highest concentrations of them are in Texas and Oklahoma. Oil and gas wells can be found in both suburban and rural locations and large densities of them are close to major metropolitan areas such as Los Angeles, Houston, Dallas, Detroit, Pittsburg, and Cleveland (Figure 1)

These idle oil and gas wells have traditionally been viewed as a liability by both operators and regulators because they have no secondary use once oil and gas production ends and they also pose significant risks to the environment, public health, and climate. However, because of the vertical displacement potential of these wells, they represent a vast and growing untapped resource that can be harnessed for gravity-based energy storage. The number of inactive wells in the U.S. has been steadily increasing over the last 30 years, according to the EPA[1], at a rate of about 1% annually. In every year since 1990, between 30,000 and 50,000 wells reached the end of their productive life in the U.S.. Drilling for new oil and gas wells is expected to continue in the coming decades, wells that will also at some point become inactive.

Figure 2 provides a framework for analyzing all oil and gas wells as a vertical displacement resource for gravity storage. Some wells are unfeasible for gravity storage conversion due to depth or geometric factors. Out of the feasible wells, those that are readily available can be categorized as "displacement reserves". This category includes inactive but unplugged wells. Similarly, contingent reserves are those wells that are currently active and will form part of the reserves once they reach their end of life. Another type of contingent reserves are the wells that have been already plugged. These wells might be suitable for conversion but since they have been fully decommissioned, they pose a bigger engineering and regulatory challenge and are therefore not readily available for conversion.

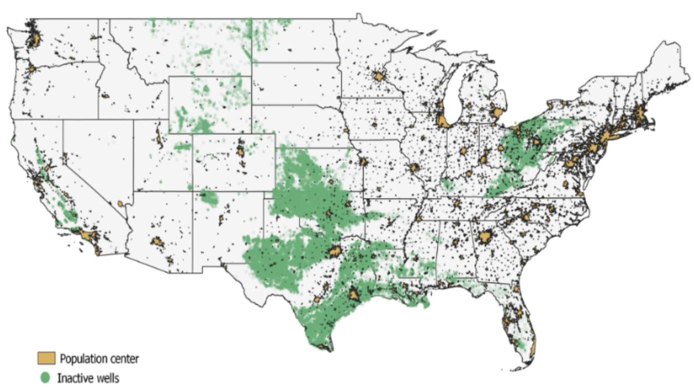

Figure 1. Location of inactive wells in the USA

3.4 Million abandoned oil and gas wells in the USA

497,000 deep inactive wells

108 GWh currently available potential gravity storage

Conversion feasibility for inactive wells

Among the factors that determine the suitability of a well for gravity storage, depth is the most important since the energy storage capacity of a given well increases proportionally with the square of depth. Assuming 3,000 feet as the minimum depth for a well to be suitable for conversion due to technical and economical factors. In the U.S., there are over 497,000 currently inactive wells with at least that required depth.[2] Assuming a depth-varying storage capacity and an 85% efficiency, these inactive wells add up to 108 GWh of storage potential.[4]

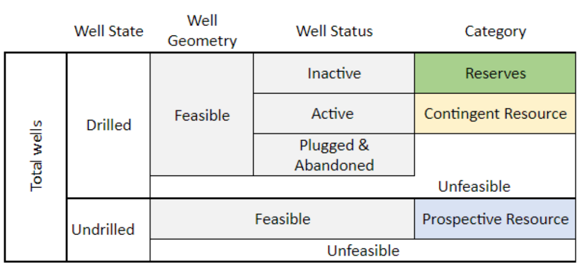

Figure 2. Categorization of the vertical displacement resources

For a 1-hour discharge rate for gravity wells, 108 GWh accounts to 4.4 times the total installed storage power capacity of the U.S. as of 2021 and almost 5 times the current capacity of pumped storage hydropower.[3] Including active wells into the displacement reserves means the potential resource more than doubles (Figure 3) reaching 257 GWh. This potential could be reached within the next 20 years if active wells keep reaching the end of their productive life at the current rate.

Other factors can affect the feasibility of converting an oil or gas well into a gravity well. Inclination and twisting of the wellbore (dogleg severity) can reduce the efficiency to the point of making the installation unfeasible. If only 20% of the wells over 3,000 feet are suitable for conversion, 21 GW of gravity-stored power would be available with currently inactive wells, this is about the same amount of storage currently installed for pumped hydropower.

Regional disaggregation for gravity storage

Approximately 90% of the gravity well storage reserves are concentrated in seven states, with Texas holding 50% followed by Oklahoma with 8%. Louisiana, Wyoming, New Mexico, Colorado, and North Dakota complete the picture. Similarly, Texas holds 50% of the potential storage that currently active wells could have once decommissioned.

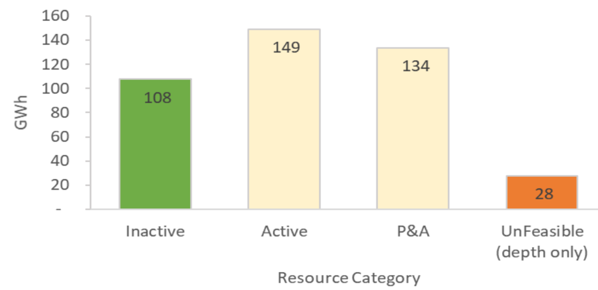

Figure 3. Estimated storage potential for different categories of wells

California holds 5.7 GW of potential storage in currently inactive wells. Even if that number pales when compared to states like Texas, it represents around 10% of the California Public Utilities Commission (CPUC), California Energy Commission (CEC), and California Air Resources Board (CARB) estimated energy storage needed for California to meet SB100.

It is clear oil and gas wells provide a substantial vertical displacement resource that can be readily tapped for gravity storage. Moreover, most existing oil and gas wells are already connected to the electric grid, and they are in regions where larger penetrations of renewable energy are expected in the future. As the need for both energy storage and idle well remediation increases, repurposing would-be liabilities into storage assets will help drive the energy transition.It is Renewell Energy's mission to repurpose oil and gas infrastructure as gravity-based energy storage.

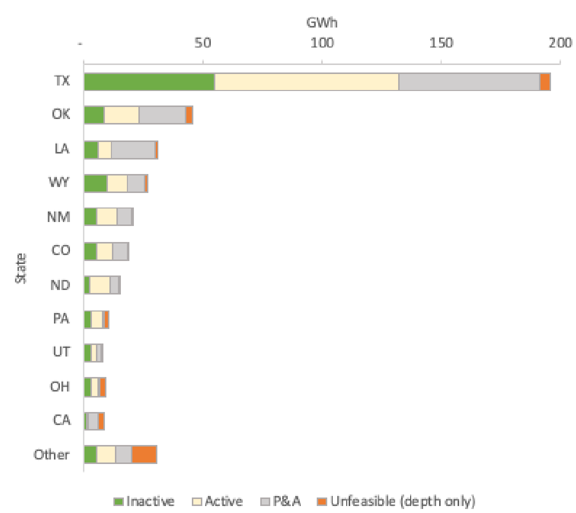

Figure 4. Estimated storage potential by state

References

1. EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks 2021
2. Enverus, 2021
3. U.S. Energy Information Administration, Preliminary Monthly Electric Generator Inventory May 2021
4. See Renewell's whitepaper on Converting Wells to Energy Storage for a more detailed methodology