Environmental Risk to Baseload Energy: How Texas Could Retrofit Zombie Wells into Closed-Loop Geothermal Systems

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Executive Summary

Texas has more than 8,000 idle or orphaned oil wells, "zombie wells" that leak methane, that threaten groundwater, and impose more than $1 billion in plugging liabilities on operators and taxpayers. Recent advances in closed-loop geothermal technology now make it technically feasible to retrofit many of these wells into sealed heat-exchange systems capable of generating base-load, carbon-free electricity. This white paper quantifies the economic upside, outlines regulatory and financing barriers, and offers a step-by-step policy roadmap to accelerate pilot projects and scaled deployments across the state.

This white paper outlines a roadmap for policy and regulatory reform:

1. How to identify "geothermal-ready" idle wells using depth, casing-integrity, and formation-temperature criteria that can be pulled directly from Railroad Commission data,
2. Step-by-step permit pathway from site screening to consolidated Railroad Commission approval that can shorten retrofit timelines to 90 days; and
3. Demonstrating how redirecting up 80 percent of a plugging bond toward retrofit Capital Expenditure (CAPEX) can turn a liability into a positive-NPV project for operators.

THE PROBLEM: COSTLY LIABILITIES BENEATH OUR FEET

Texas has long been the nation's energy workhorse, drilling more than one million oil and gas wells since the Spindletop discovery. As fields mature, however, thousands of wells slip into the "orphan" status: wells that have been inactive, non-compliant for a minimum of 12 months and the operator has been delinquent for greater than 12 months:

- **~9,000** documented orphan wells;[i] plugging backlog grows ~10 % per year.
- Methane leaks equal to an estimated **253.1 BcF** annually[ii] eroding Texas' air-quality goals.
- Plugging cost can soar up to **$76,000 per well** with some cases reaching **$1 million.**[iii]
- Rural landowners face depressed property values and groundwater risks; state regulators face mounting reclamation bills.

In short, the state faces a compounding environmental and fiscal liability. The cost of doing nothing is more methane in the atmosphere, more public dollars spent on remediation, and a missed chance to extract additional economic value from existing subsurface assets.

TECHNOLOGY PRIMER: CLOSED-LOOP GEOTHERMAL SYSTEMS

Texas has long tapped subsurface resources for oil and gas; while still in the prototype stage, closed-loop geothermal repurposes that expertise for heat instead of hydrocarbons. In a closed-loop system, a sealed working fluid circulates through a wellbore, absorbing heat from the surrounding formation before returning to the surface to drive a turbine. Because the loop is sealed and does not involve fracture creation, **no produced water is brought to the surface**, eliminating induced-seismicity and water-handling concerns that attach to conventional hydrothermal projects.

Recent pilot wells in Houston[iv] and California[v] show that stable outlet temperatures of 140-180 °C were more than enough for binary-cycle power production while early cost projections suggest parity with new gas peakers once scale economies kick in. By leveraging existing wellbores, Texas can sidestep a major portion of drilling expenditures (CAPEX) and mitigate the environmental footprint associated with green field geothermal. In short, closed-loop technology translates the state's drilling heritage into a next-generation baseload resource that is both dispatchable and emissions-free.

Feature	Conventional Geothermal	Closed-Loop Retrofit
Fluid	Native brine	Sealed working fluid
Fracking	Often Required	Not Required
Water use	High	Minimal
Emissions	97% less SO_2, 99% less CO_2[vi]	Near-Zero
Retrofit Potential	Limited	High for idle wells with adequate depth/temp

Beyond these core advantages, several design variants allow closed-loop retrofits to match diverse well conditions:

- Coaxial Tubing – A production string inside the existing casing forms a "tube-within-a-tube"; hot fluid rises in the inner tube while cooler fluid descends in the annulus, maximizing heat extraction without cementing new liners. This has the lowest thermal potential.

- U-Tube or Multilateral Loops – Where sidetracks exist, a U-tube configuration further increases surface area and heat sweep, boosting output without additional drilling footage.

- Downhole Heat Exchangers – In wells with excellent bottom-hole temperature but compromised casing, an entirely new sealed heat exchanger can be lowered, isolating the working fluid from corroded pipe.

Most retrofits will pair with binary-cycle Organic Rankine Engines, converting outlet fluid at 140-180 °C into 24/7 electricity with efficiencies of 10-15 percent. For shallower wells (100–120 °C), closed-loop heat can still drive district heating, lithium brine pre-heating, or on-site desalination creating stacked revenue streams even when electric levelized cost of energy (LCOE) is marginal.

By marrying proven oil-field hardware with next-generation heat-extraction methods, closed-loop geothermal retrofits offer Texas a practical bridge from its hydrocarbon past to a resilient, carbon-free energy future.

GEOTHERMAL ENERGY STORAGE

While geothermal energy is traditionally viewed as a baseload resource, emerging technologies now enable its use as a thermal energy storage medium. This new form of long-duration energy storage complements both renewable and dispatchable generation. By circulating working fluid through closed-loop systems during periods of excess wind or solar generation, heat can be stored in subsurface formations and released later to produce power during peak demand or low-renewable intervals.

This "charge–discharge" capability transforms geothermal reservoirs into thermal batteries with multi-day duration and negligible degradation. This new method of storing excess energy through batteries will provide a needed relief for both operators of large energy users like data centers, and manufacturers, who are looking for opportunities to reduce ERCOT grid strain and ensuring that the PUCT isn't passing these energy user's costs onto consumers.

ECONOMIC OPPROTUNTIY

ERCOT's rapid influx of solar and wind has lowered marginal energy prices but increased the demand for firm, clean capacity that can respond when the wind calms or the sun sets. Retrofitted geothermal wells deliver exactly that attribute.

Unlike gas peakers, they require no fuel deliveries or hedging, and unlike batteries, their output does not degrade over a multi-day weather event. For rural counties wrestling with orphan-well liabilities, the conversion offers dual relief: avoided plugging expenses and a new taxable generation asset.

At the workforce level, the overlap between drilling, completions, and geothermal retrofit work is increasingly similar, allowing floorhands, wireline crews, and rig hands to pivot into long-lived clean-energy jobs with minimal retraining.

The opportunity is not theoretical; venture-backed firms have already secured PPAs in Nevada[vii] providing real-world data points for Texas legislators and investors to benchmark.

POLICY GAPS

Despite technical feasibility, market uptake in Texas is stalled by a regulatory framework built for either hydrocarbon production or traditional geothermal, with no streamlined lane for retrofit wells. The Railroad Commission's plugging rules make no distinction between a well destined for cement and a well poised for conversion, locking operators into a liability mindset rather than a redevelopment mindset. Meanwhile, county tax appraisals often spike the moment a renewable project is announced, undercutting project finance.

On the grid side, ERCOT still lacks a standardized small-generator interconnection pathway for sub-5 MW geothermal units, forcing project developers into bespoke negotiations that add cost and delay.

Finally, bonding and royalty structures do not yet reward methane-leak avoidance or groundwater protection—two public benefits that closed-loop retrofits inherently deliver.

Without targeted statutory tweaks and clear agency guidance, the default outcome is to pay $35k – $100k per well to abandon a resource that could produce revenue and resilience for decades.

1) No asset-screening tool to identify geothermal-ready wells.

2) Bonding rules treat retrofit and abandonment identically, removing economic incentive.

3) The Permitting path unclear: geothermal retrofits would be regulated under multiple, sometimes conflicting, statutes.

4) Lack of standardized Power Purchase Agreement (PPA) structure for small-scale baseload supply into ERCOT.

RECOMMENDATIONS FOR LAWMAKERS

1) **Create a "Geothermal-Ready Well Registry."**
Texas Railroad Commission (RRC) and UT Bureau of Economic Geology compile depth, casing integrity, and formation temperature data.

2) **Establish Bond-for-Retrofit Credits.**
Allow operators to apply up to 80 % of plugging bond toward retrofit CAPEX if the well is converted within 24 months. Eventually, the legislature should create a "retrofit fund" that allows complete mitigation of zombie wells.

3) **One-Stop Permit Desk.**
Authorize RRC to issue a consolidated geothermal retrofit permit within 90 days, coordinating TCEQ and surface-owner approvals.

4) **Pilot-Project Tax Incentive.**
Five-year ad-valorem tax abatement for the first MWs of closed-loop capacity brought online if connected to ERCOT grid.

5) **Standardized 10-Year Baseload PPA Template.**
ERCOT and PUC provide an off-the-shelf contract for utilities purchasing output from retrofitted wells ≤5 MW.

References and Endnotes

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