West Virginia University
Bridge Initiative for Science and Technology
Policy, Leadership, and Communications

Legislative Science and Technology Note

Potential Lithium Extraction from West Virginia Natural Gas Activity

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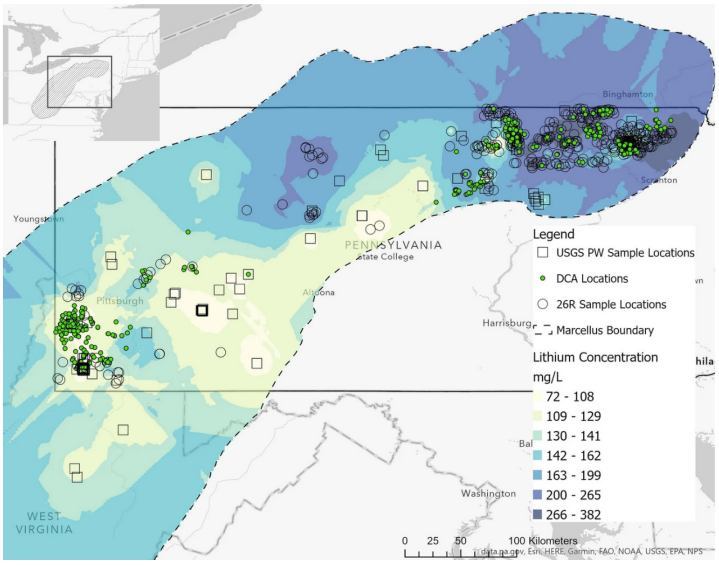
Lithium (Li) is an element used in cell phones, pharmaceuticals, military technologies, electric vehicles and more, often in the form of rechargeable lithium-ion batteries. The United States Geological Survey (USGS) classifies lithium as a critical mineral. A recent scientific paper published in the journal Nature found that it may be possible to extract significant amounts of lithium (up to 40% of US annual consumption) from Marcellus Shale gas production wastewater in Pennsylvania. These results could also apply to Marcellus wells in West Virginia. The Marcellus Shale is a geological formation beneath parts of Pennsylvania and West Virginia (see figure). This Science and Technology Note considers potential challenges and benefits of pursuing lithium co-production with natural gas in West Virginia.

Research Highlights

- Recent studies indicate that it may be economically feasible to extract lithium, a critical material, from water produced alongside natural gas operations.
- West Virginia's existing natural gas industry positions it well to potentially lead in this emerging area. However, economic, technical, and environmental factors contribute risk to this course of action.
- Policy options include tax credits, equipment rebates, or studies to further explore the potential for lithium co-production with natural gas in West Virginia.

West Virginia Challenge and Opportunity

West Virginia has extensive natural gas operations, producing nearly three trillion cubic feet of natural gas in 2023. These operations bring large amounts of water (over fifty million barrels by West Virginia in 2023), called produced water, to the surface. Marcellus Shale produced water contains relatively high concentrations of lithium in the hundreds of milligrams per liter (mg/L) (see figure). At present this water (also called oil field brine) is usually minimally treated and reused for further hydraulic fracturing or transported to saltwater disposal wells where it is injected deep underground for storage.



Lithium concentration map. Source: Mackey et. al., Nature (2024).

Currently lithium is primarily either mined directly from hard rock (spodumene) and processed, or extracted from underground saltwater brines left to purify in large evaporation ponds. To extract lithium from West Virginia produced water would require direct lithium extraction technologies, which are not yet fully mature. However, researchers Mackey et. al. estimate that a single Marcellus natural gas well in SW PA could produce nearly 3 metric tons of lithium over its ten year lifespan. (Annual US lithium consumption is roughly 3,000 metric tons.) Sustained produced water lithium production would require continuous addition of new Marcellus wells. Extracting lithium from produced water has the potential to turn an economic and environmental liability into an asset and to help offset the costs of PW management, spurring economic development in West Virginia. However, technical, economic and environmental hurdles remain.

The feasibility of extracting lithium from produced water from natural gas operations depends upon the location and characteristics of the play, the produced water treatment cost, and the market price of the element. While global demand for lithium is expected to grow, its market price has been inconsistent, decreasing significantly in recent years. New production of lithium

could overtake demand, affecting market prices. However, there are potential economic advantages of co-production with natural gas because produced water is already extracted and some treatment infrastructure is already in place.

Costs of the required processing of produced water will depend on the technologies deployed and required infrastructure, along with the characteristics of the produced water. Lithium concentrations in produced water can vary significantly with location (see figure), and other characteristics (well-decline time, permeability of rock, concentration of magnesium) can be more important for lithium yields. For example, Mackey et. al. estimate that average lithium production would be higher in SW PA than NE PA due to slower well-production decline, despite lower lithium concentrations. This suggests West Virginia location specific studies in West Virginia could better inform the economic and technical feasibility of lithium-natural gas co-production potential in the state.

Benefits and Drawbacks of Action

Taking actions to incentivize lithium co-production with natural gas could benefit West Virginia natural gas producers and the economy. It could create jobs constructing lithium extraction modules, and developing and maintaining various produced water treatment and separation technologies. It could offset produced water treatment costs, and potentially give new life to depleted West Virginia Marcellus wells. Co-production of lithium with other critical materials and potable water could be pursued. Extracting lithium from produced water requires less energy and water than hard rock mining of lithium. Potential downsides include increased energy and water demands compared to existing produced water treatment, and required management of new byproducts of treatment (including potentially low-level radioactive material). There are risks of groundwater contamination if these wastes are not managed carefully. The need to expand natural gas operations to maintain lithium production levels and its associated environmental impacts should be considered.

Existing Commercial Activity

There is currently not large-scale commercial extraction of lithium from produced water or lithium co-production with natural gas. However, several pilot-scale research and commercial projects are under development. Direct lithium extraction techniques are commercially available and are in commercial use in other industries. These technologies could soon be in use in major lithium producing countries. Oil companies are investing in direct lithium extraction technologies. Two pilot scale projects are led by Standard Lithium Ltd. in the Smackover formation in Arkansas: the South West Arkansas Project would use currently exploited oil and gas infrastructure, and is targeting first production in 2027. The Phase 1A project is a brownfield development project that will process brine tailings from an existing bromine facility. Each plans to produce over 12,000 tons of lithium per year (four times the annual US consumption). A Standard Lithium demonstration plant in Arkansas boasts being the only commercial-scale plant in North America. Lithium concentrations in Smackover formation brines are on average several times higher than West Virginia based on existing data. ExxonMobil also plans to produce lithium from Smackover brines. Commercial lithium development from oilfield brine is also being pursued in Alberta, Canada, where lithium concentrations are reportedly below 80 mg/L. E3 Lithium Ltd.'s Clearwater Lithium Project pilot began construction in 2023 and ultimately seeks to produce over 12,000 tons of lithium a year.

Relevant State Policies and Policy Options

West Virginia has been a leader in legislative action regarding critical minerals in recent years. In 2023, HB 3012 exempted lithium (and other critical minerals) from severance taxes for a period of nine years. As introduced, HB 4971 (2024) would have declared it West Virginia state policy to promote critical materials (including lithium) manufacturing in the state and provided property tax relief for critical materials manufacturing equipment. As passed, however, HB 4971 (enrolled) provides property tax relief only for silicon and silicon carbide manufacturing equipment. The final version also removed the section promoting critical materials manufacturing. In 2024, Louisiana passed (SB 268) a one-year sales tax rebate for relevant equipment purchased in Louisiana by companies involved in a qualified lithium recovery project. South Dakota attempted to pass a lithium severance tax in 2023 (HB 1072) but this bill failed. California's SB 471 (2023) would allow tax credits to those involved primarily in the business of lithium or electric battery manufacturing, but stalled in committee.

Future policy options include attempting to incentivize lithium co-production with natural gas via equipment tax rebates as in Louisiana or income tax credits. Another option is to form a commission to further study the issue as ongoing research and commercial activity develop.

This Legislative Science & Technology Note was written by Ryan Nesselrodt, PhD, West Virginia Science and Technology Policy Fellow, on behalf of the Bridge Initiative for Science and Technology Policy, Leadership, and Communications. Please see https://scitechpolicy.wvu.edu/ or contact scitechpolicy@mail.wvu.edu for more information.