CCST REPORT
Long-Term Viability of Underground Natural Gas Storage in California

Report Published **JANUARY 2018**

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WHAT IS UNDERGROUND GAS STORAGE?

- **Definition:** Underground gas storage (UGS) is the injection of natural gas, which is predominantly methane, through wells drilled into geologic formations deep underground (ranging 1 to 2 miles in depth), for storage and later withdrawal. In general, UGS reuses caverns originally containing and already mined for salts, or the pore spaces of sedimentary rock originally containing saline water or oil or natural gas.
- **Usage:** The general purpose of UGS is to store natural gas to meet varying demand over hourly to seasonal time scales. In short, UGS facilities take natural gas from the transmission pipeline during periods of low demand and they compress, inject, contain, withdraw, and process the gas for delivery back to the transmission pipeline during periods of high demand. UGS facilities could also be used to store biogas (gaseous fuel generated from agricultural and other organic waste) or hydrogen, as well as sequestration of carbon dioxide.
- **The California UGS System:** The California UGS system in 2017 comprised 12 facilities: four in southern California, seven in northern California, and one in central California. All of the UGS facilities in California store natural gas in depleted natural gas or oil reservoirs.

THE ROLE OF UGS AND NATURAL GAS IN CALIFORNIA'S CURRENT ENERGY SYSTEM

- **State Reliance on Natural Gas:** California's energy system currently requires natural gas and UGS facilities to run reliably, primarily because many residential and commercial buildings in California rely on natural gas for heating during the winter, and because natural gas provides electricity when sufficient solar/wind power are not available.
- **UGS Allows State to Meet Energy Demand During Peaks:** California's UGS facilities send natural gas to customers when the State's gas pipelines cannot import gas fast enough to meet consumer demand. These facilities store gas during periods of low demand and provide gas during periods of high demand – for example, for heating on cold winter days, or for generating electricity for air conditioning on hot summer days.
- **UGS Capacity in California at Maximum:** The current configuration of the energy system in California requires essentially all of the State's available UGS capacity for energy reliability. Currently, UGS facilities regularly obviate the need for California to curtail natural gas delivery during multiday cold winter condition. They also allow for smooth daily operations of electric generators, and help stabilize energy prices on the California grid.

RISKS OF UGS FACILITIES TO HEALTH, SAFETY, ENVIRONMENT, AND INFRASTRUCTURE

- **Potential Hazards and Risks:** Natural gas is flammable, contains small amounts of toxic air pollutants, and is transported and stored at high pressure. Large-scale loss-of-containment (LOC) events, such as well blowouts, may constitute threats to safety and loss of life, in addition to potential environmental impacts and impacts to the UGS infrastructure itself. Human health hazards of natural gas LOC include exposures to toxic air pollutants, as well as to explosions and fires. Environmental hazards include the potential underground escape of gases and other fluids associated with UGS processing into groundwater resources, as well as increases in greenhouse gas (GHG) emissions during LOC events. New regulations in California on well construction, well-integrity monitoring, and risk management promise to greatly reduce risks associated with LOC incidents.
- **Assessing Risk:** Opportunities to manage risks at UGS facilities can be assessed across key subsystems: human (e.g. operator training), organizational (e.g. accountability protocol), technological (e.g. mechanical design), and environmental (e.g. proximity to populations).
- **Potential Vulnerabilities Differ Facility-to-Facility:** A comparison of hazards and vulnerabilities across the individual UGS facilities in California suggests that a few facilities have relatively higher risk compared to others. These include facilities that are located in seismic or other natural disaster hazard zones, or are located near large population centers. For example, the Playa del Rey facility, which has a long history of loss-of-containment incidents and is located near a large population center in a very high wildfire hazard zone, has relatively higher risk to health and safety than the other facilities in California. Aliso Canyon, Honor Rancho, and La Goleta also present higher health and safety risks than other facilities because of their locations near large numbers of people.

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SELECT EXPERTS

The following researchers can advise and share insights on underground natural gas storage in California.

AMBER J. MACE, PhD
Deputy Director, CCST
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Dr. Mace can speak on the overall findings of the 2018 CCST report on UGS and the report process.

JENS T. BIRKHOLZER, PhD
Senior Scientist and Director,
Energy Geosciences Division
Lawrence Berkeley National Lab
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Dr. Birkholzer can speak on the risks of California's UGS facilities, and how these risks can be managed and mitigated.

JEFFERY GREENBLATT, PhD
Staff Scientist
Lawrence Berkeley National Lab
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Dr. Greenblatt can speak on projections of California's future energy system (including electricity supply and demand, building energy use, and transportation technologies); California's future UGS needs; and the State's energy and climate change policies.

JANE C.S. LONG, PhD
Independent Scientific Consultant
janecslong@gmail.com

Dr. Long can speak on the current use of UGS; the current role of UGS facilities for energy reliability; near-term and long-term alternatives to UGS; and UGS integrity and risks.

CURTIS M. OLDENBURG, PhD
Senior Scientist and Lead,
Energy Resources Program Domain
Lawrence Berkeley National Lab
cmoldenburg@lbl.gov

Dr. Oldenburg can speak (and recommend additional experts) on the physical characteristics of UGS in California; well blowout processes and well modeling; risk management; factors contributing to well integrity; likelihood of failure of UGS facilities; and environmental and human health risks of UGS.

2018 CCST REPORT ON LONG-TERM VIABILITY OF NATURAL GAS IN CALIFORNIA

In response to **Governor Brown's** January 2016 state of emergency proclamation regarding the Aliso Canyon gas leak, **SB 826 (Leno, 2016)** requested that the **California Council on Science and Technology (CCST)** provide the State with up-to-date information on all currently operating underground natural gas storage fields in California. CCST was instructed to provide an independent technical assessment answering three key questions about:

- **The risks California's underground gas storage facilities pose to health, safety, environment, and infrastructure;**
- **Whether California needs underground gas storage to provide for energy reliability through 2020; and**
- **How implementation of California's climate policies changes the future need for underground gas storage.**

From a statewide field of leading energy researchers, CCST selected Jens T. Birkholzer, PhD, and Jane C.S. Long, PhD, to serve as co-chairs of the 12-member **CCST Report Steering Committee** – which supervised 21 Report Authors with expertise spanning hydrogeology and reservoir engineering, risk assessment, public and occupational health, greenhouse gas (GHG) emissions, and energy analysis and economics. Each report chapter was subject to a peer review process by independent experts, while another independent expert served as Report Monitor to oversee the process, ensuring that peer review comments were sufficiently addressed in the final report. An additional Oversight Committee reviewed the entire process, including conflict-of-interest declarations.

FINDINGS AND CONCLUSIONS

The report's findings and conclusions are based on a review of published literature and official and voluntary databases, which the Report Authors compiled between January through September 2017, and delivered to the **California Public Utilities Commission** in January 2018. Key findings and conclusions include (See the Full Report for additional findings and conclusions):

- **Safety:** The risks associated with underground storage (UGS) facilities can be managed, and, with appropriate regulation and safety management, may become comparable to risks in other types of energy facilities found acceptable in California, such as oil refineries and natural gas power plants. At each UGS facility, the State should ensure timely and thorough implementation of the new regulations coming into force in 2018 set by the California Department of Conservation's Division of Oil, Gas, and Geothermal Resources (DOGGR). Those regulations emphasize new and safer well completions, risk and safety management plans, and requirements for well integrity testing and monitoring. The report recommends that the State go further and require more quantitative risk assessment activities, including consideration of human and organizational factors affecting risk. The State should also implement an independent and mandatory review program to evaluate the effectiveness of these new regulations and the rigor of their application in practice, with opportunity for public comment and public dissemination of the review results.
- **Facility-by-Facility Evaluation:** Any industrial operation involves some risk to health, safety, and environment. This report assessed various risk-related characteristics across UGS facilities in California, and found a small list of facilities had relatively higher potential risk compared to others.
- **Reliability of Natural Gas Supply:** California's energy system currently requires natural gas and UGS facilities to run reliably, primarily because many residential and commercial buildings in California rely on natural gas for heating during the winter, and because natural gas provides electricity when solar and wind power are not available. The peak demand for natural gas during the winter currently exceeds the ability of pipelines to bring natural gas into the State of California, so natural gas must be stored during periods of low demand in order to have it available to meet peak demand.
- **Near-Term Alternatives to UGS:** Closing any or all UGS facilities in the near term would involve replacing UGS facilities with new pipelines or natural gas storage capacity, and require very large investments. Such new natural-gas-related infrastructure would bring its own risks and would further obligate the State to the use of natural gas for decades. The risks, costs, and benefits associated with alternatives to UGS storage should be evaluated accordingly.
- **Long-Term Need for Underground Gas Storage:** California's climate policies in future decades could still necessitate the continued use of natural gas. Also, energy systems that meet the climate goals may require underground storage of natural gas, biogas, or hydrogen, as well as sequestration of carbon dioxide. The State should develop a more complete and integrated plan to understand how the role of natural gas might evolve; assess possible energy portfolios that both meet GHG emission constraints and achieve energy reliability; and consider the potential need for UGS facilities in the future.

REFERENCES

The following resources form the basis of this summary:

Long-Term Viability of Underground Natural Gas Storage in California:
An Independent Review of Scientific and Technical Information (Executive Summary, Summary Report, and Full Report)
Jens Birkholzer and Jane C.S. Long, Report Steering Committee Co-Chairs. California Council on Science and Technology, January 2018.
https://ccst.us/reports/long-term-viability-of-underground-natural-gas-storage-in-california-an-independent-review-of-scientific-and-technical-information/

A CCST Commissioned Report requested by the California State Legislature, delivered to the the California Public Utilities Commission as directed by the Governor of California.

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