



SMRI Request for Proposal (RFP2023-03) “H2 - Natural Gas Blends Stratification Potential in Caverns”

1. Background

Many operators are currently studying the conversion of their natural gas storage sites to hydrogen, either 100% or with a blend.

One of the knowledge gaps is the mixing behavior and possible stratification of hydrogen and natural gas, resulting from the competition between the lower density of H₂ when compared to natural gas molecules (that tends towards stratification) and the diffusion and convection at play in the cavern (that tend towards homogeneous mixing of all gas molecules). This topic has two applications related to hydrogen storage in salt caverns.

In case of a blend the possibility to have an accumulation of hydrogen in the upper part of the caverns, behind the operating gas tubing if it extends below the roof of the caverns, or in the cavern neck and casing above the tubing end has to be assessed.

In the case of the conversion of existing natural gas caverns to pure hydrogen, recent research works (Keßler, 2021; Keßler and Bültemeier, 2020) have investigated a conversion without previous rebrining: pure hydrogen is injected in the annulus of the cavern well and natural gas is produced through an inner conversion string. The investigations through numerical studies by Keßler (2021) suggest a clear separation between hydrogen and natural gas develops with a relatively small transitional mixing zone in the gas cavern. A summary of these findings are discussed in SMRI report RR2023-1 §3.15. However, since the flow behavior in a cavern is strongly dependent on the cavern geometry and other local-specific conditions, it may vary quite significantly from the presented simulation, and these simulations would need to match observations to further demonstrate this conversion option.

2. Scope of Work

The objective of this research proposal is to study both application cases with numerical tools and/or in situ testing/ test at the lab scale and/or by analyzing cavern scale data from historical experience (notably, Town gas storage in salt cavern and former technique of H₂ injection as a tracer in gas caverns can provide key cavern-scale observations).

The scope of work would be to;

- 1) study the theoretical physics at play in this area of the caverns/wells (convection, gravity forces, diffusion,...) and summarise how these impact behaviour between hydrogen and natural gas.
- 2) create a model able to simulate the behaviour of natural gas and hydrogen within cavern. The model shall:
 - a. be capable of modelling different blends of hydrogen and natural gas (up to 100% hydrogen / natural gas).
 - b. be capable of assessing different cavern configurations and operating conditions: Including

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- different cavern shapes / sizes, well design, flow rates (import and export)
- c. output an understanding of gas composition of cavern contents over time depending on different scenarios.
- 3) The model results will be verified by either benchmarking against industry experience or through lab scale testing or in-situ in a real cavern (if available).

References:

Keßler, Benjamin. 2021. "Thermodynamisches Verhalten von Erdgas, Wasserstoff und Erdgas-Wasserstoff-Mischgasen in Salzkavernen während der unterirdischen Speicherung." PhD dissertation, TU Freiberg, 21.12.2021

Keßler, Benjamin, and Hagen Bültemeier. 2020. 'Thermodynamische Modellierung der Umstellung von Erdgaskavernen auf Wasserstoff', *gwf Gas + Energie* 9/2020.

RR 2023-1. Hydrogen Storage in Salt Caverns Current Status and Potential Future Research Topics. SMRI Research Report, 17 April 2023.

3. Proposal Instructions

Responses to this RFP should be reasonably brief (less than 10 pages), describe the proposed effort and offer a succinct discussion of the technical approach.

This RFP anticipates that a fixed-sum contract will be used, and a project schedule and cost plan will be submitted.

The qualifications and experience of the proposed researcher(s) in the technical field described within the Scope of Work are likely the most significant proposal-evaluation criteria.

Teaming and subcontracting to bolster qualifications are encouraged, but a strong lead researcher (project manager) must be identified in the proposal and will be named in the research contract as key personnel. The level of commitment of the lead researcher to the research effort must be itemized in the proposal.

Proposals should be submitted in electronic form via email to Tim Bauer, SMRI Research Coordinator, (tbauer@solutionmining.org), by 31 January 2024. Please email a statement of your interest or intentions to respond to this RFP before 29 December 2023, so you can receive any updates or modifications to this RFP. Questions relating to this RFP should be directed in writing (via email) to the Research Coordinator. Answers to questions that apply to all potential proposers will be forwarded to all identified proposers.

4. Contract Award and Contract Specifics

Proposals will be evaluated solely based on information contained in the proposal. The proposer selected for negotiation of a contract will be the one that best meets SMRI's needs and is economically sound. SMRI has the right to select or reject any or all proposals.

The research contract will be negotiated between the selected contractor and SMRI. The contractor will be solely responsible for coordination of any subcontracted work and for all payments to any sub-contractor(s).

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1. SMRI contract for this Work will be fixed sum for the defined statement of work. The proposed fixed-sum payment must be clearly defined in the proposal. Payment will be made upon acceptance by the Research Committee of the final research report. No other progress or interim payments would normally be made.
2. SMRI's Project Sponsor will be named after contractor selection. The Project Sponsor will be the contact for any project-related communications.
3. The research project is to be completed within the time frame agreed on for the project.
4. The contractor shall present progress reports at each SMRI Research Committee meeting during the project and an oral research report at the end of the project. The costs for these presentations, if any, are to be included in the fixed-sum cost of the project. The Project Sponsor or Research Coordinator may present one of the two required progress reports per year to the Research Committee using materials (text and PowerPoint) prepared by the project team.
5. A final research report is required in the form of a standard scientific or technical report. The research report will provide standard information such as background and purpose for the research, theoretical basis and methods, data collected, analysis, references, and research conclusions. Depending on the amount of information used, either lists of information in appendices or separate electronic files of the information, or both, might be required. All report submittals (drafts-for-review and final) will be as electronic files, both MS-WORD (*.doc) and PDF (*.pdf). SMRI will supply formats/contents for its standardized report covers, title pages, and forward/disclaimer for its research reports. The research report will be reviewed by the Project Sponsor, the Research Coordinator, and the Research Committee. Before final report acceptance, the researchers must satisfactorily address all review comments.
6. The enclosed Standard Terms and Conditions for SMRI Research Contracts, dated 3 January 2023, shall apply. Additional limitations or modifications are possible before contract negotiation.
7. SMRI retains ownership and copyright of the work products resulting from this research. Limitations on publishing and release of information are listed in the Terms and Conditions.

Tim Bauer
Research Coordinator

Enclosures:

Standard Terms and Conditions for SMRI Research Contracts, dated 3 January 2023

Cc: John Nadeau, Executive Director
Andreas Reitze, 2023 SMRI President
Daniel Noack, 2023 SMRI Research Chairman
Members of the SMRI Research Committee

SMRI RFP2023-03_H2 Nat Gas Blends Stratification.pdf

**ATTACHMENT
STANDARD TERMS AND CONDITIONS**



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Standard Terms and Conditions for SMRI Research Contracts **3 January 2023**

1. The contractor shall perform the scope of work and submit the contract deliverables specified in the Request for Proposals (RFP) and the contractor's proposal. If differences exist between the RFP and the contractor's proposal, the RFP shall govern, unless otherwise specified in the contract. All written or electronic communication regarding the research is to be in English.
2. The SMRI Project Sponsor(s) will provide technical oversight to include review of project plans, will assist in resolution of any technical issues which might impact the project or research results, will approve contractor progress reports, and will review all invoices for accuracy.
3. During the project, progress reports may be given by the contractor during Research Committee meetings generally on the Saturday before SMRI conferences begin, or the brief progress reports must be given to the Project Sponsor prior to the Research Committee meetings for informing the Committee.
4. After the first draft report is approved by SMRI's Research Committee, SMRI will provide a report number, a cover page, a disclaimer regarding the report contents, and a copyright notice which will become part of the final report. A filename and format will then be designated for the final report. All draft and final versions of the research report must include the date at the end of the filename
5. The final report shall be provided in electronic format in Adobe Acrobat word searchable (.pdf) format. The electronic report may consist of text, figures, tables, maps, data files, etc. Reports in electronic format may contain color, (such that colors will print visibly in black and white). Files too large for email attachment may be sent to SMRI via an FTP site.
6. The final results of the research shall be presented in a 30-minute oral report at an SMRI meeting. The report may, at the discretion of SMRI, be at a members-only meeting, or as part of a technical conference. Any and all costs associated with the presentation are part of the contract and included in the contractor's proposal.
7. Upon SMRI acceptance of the final report, the Contractor shall send an invoice electronically to the SMRI Executive Director, Assistant Executive Director, Research Coordinator, Project Sponsor, and copy to accounting@solutionmining.org for approval and payment.
8. SMRI owns the copyright and has the sole right to distribute the report and research products in all versions and formats, including the right to charge for it. The Contractor may distribute the report without charge within the Contractor's organization.
9. SMRI has the right to cancel the contract for any reason and at any time. Should SMRI elect to do so, it shall reimburse the contractor for all costs incurred through the cancellation, unless the cancellation is due to inadequate or late performance.
10. SMRI will not pay any costs or reimburse any expenses not specifically included in the contract. Any changes to the contract must be approved in writing by SMRI and the researcher prior to such additional work or expense. Full costs of the project will be paid by SMRI upon acceptance of the final report by the Research Committee, unless partial payments are specified in the proposal and contract.