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# Quarterly Research Performance Progress Report

(Period Ending 06/30/2018)

## Kinetic Parameters for the Exchange of Hydrate Formers

Project Period (07/01/2013 to open)

Submitted by:  
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U.S. DEPARTMENT OF  
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NATIONAL ENERGY  
TECHNOLOGY LABORATORY

Office of Fossil Energy

# RESEARCH PERFORMANCE PROGRESS REPORT

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## ACCOMPLISHMENTS:

### **BP5-Task 13.0 Nitrogen Injection (KIGAM-funded, Separate, Coordinated PNNL Project #68908)**

No accomplishments to report for this task during the third quarter of FY18.

### **BP5-Task 14.0 Geomechanics Implementation and Verification**

This task is closely linked with the BP5-Task 13.0 and 15.0, as geomechanical modeling capabilities are required to complete the nitrogen injection simulations and the code comparison study problems. Accomplishments reported for BP5-Task 13.0 and 15.0 equally during this quarter equally apply to this task.

### **BP5-Task 15.0 International Hydrate Code Comparison**

During this quarter the first and second benchmark problems were finalized, solutions submitted against those problems and solutions compared. The first benchmark problem is championed by Mark White at PNNL, USA and involves straight hydrate dissociation via either thermal stimulation or depressurization. This problem was part of the 1<sup>st</sup> International Gas Hydrate Code Comparison Study, and does not include a geomechanical component. Seven teams submitted solutions to Benchmark Problem 1; University of Texas, Austin (UTA), Lawrence Berkeley National Laboratory (LBNL), University of California Berkeley (UCB), Pacific Northwest National Laboratory (PNNL), Jilin University (JLU), National Energy Technology Laboratory (NETL), and Lawrence Livermore National Laboratory (LLNL). Those solutions were compared during the IGHCCS2 teleconference series. The second problem is championed by Shubhangi Gupta, GEOMAR Kiel, Germany and is an extension of the classical Terzaghi Problem with four cases. The first case maintains the temperature outside of the hydrate stability zone; the second case yields hydrate formation and dissociation, the third case alters composite mechanical strength of the hydrate bearing layer, and the fourth case considers rapid hydrate formation and dissociation kinetics. Three teams submitted solutions to Benchmark Problem 2: GEOMAR Kiel (GEOMAR), University of California Berkeley (UCB), and Pacific Northwest National Laboratory (PNNL). Submitted solutions were compared during the IGHCCS2 teleconference series. The third benchmark problem is championed by Matt Reagan, Alejandro Queiruga, and George Moridis, at LBNL, USA and considers coupled flow,

transport and geomechanics in a radial domain. The fourth benchmark problem is championed by Sayuri Kimoto at Kyoto University, Japan and is modeled after the Nankai Trough field experiment. The study currently comprises 54 participants, representing 24 teams, from 5 countries (i.e., United States, United Kingdom, Germany, Korea, Japan, and China). A workspace within the NETL EDX system has been created for the study, and accounts have been granted for requesting participants. Five study teleconferences were held during the quarter:

- Teleconference #9: April 12, 2018
  - IGHCCS2 Benchmark Problem 2
    - Review of problem description
    - GEOMAR solutions
    - Discussion on number of simulations
  - IGHCCS2 Benchmark Problem 1
    - Review of problem questions
    - Review of submitted solutions
    - UT Austin, LBNL, UC Berkeley, PNNL
  
- Teleconference #10: April 26, 2018
  - IGHCCS2 Benchmark Problem 1
    - Review of submitted solutions
    - Discussion of numerical approaches
    - Discussion of difficulties
    - Submitted Solutions
      - University of Texas, Austin (UTA)
      - LBNL, UC Berkeley, PNNL, JLU, NETL
  
- Teleconference #11: May 10, 2018
  - IGHCCS2 Benchmark Problem 1
    - Review of submitted solutions
    - Discussion of numerical approaches
    - Discussion of difficulties
    - Submitted Solutions
      - University of Texas, Austin (UTA)
      - Lawrence Berkeley National Laboratory (LBNL)
      - University of California Berkeley (UCB)
      - Pacific Northwest National Laboratory (PNNL)
      - Jilin University (JLU)
      - National Energy Technology Laboratory (NETL)
  
- Teleconference #12: May 31, 2018
  - IGHCCS2 Benchmark Problem 1
    - Update of submitted solutions
    - Submitted Solutions
      - University of Texas, Austin (UTA)
      - Lawrence Berkeley National Laboratory (LBNL)
      - University of California Berkeley (UCB)
      - Pacific Northwest National Laboratory (PNNL)
      - Jilin University (JLU)
      - National Energy Technology Laboratory (NETL)
  - IGHCCS2 Benchmark Problem 2

- Review of Problem Description
- Review of Submission Template
- Teleconference #14: June 21, 2018
  - IGHCCS2 Benchmark Problem 1
    - Update of submitted solutions
      - University of Texas, Austin (UTA)
      - Lawrence Berkeley National Laboratory (LBNL)
      - University of California Berkeley (UCB)
      - Pacific Northwest National Laboratory (PNNL)
      - Jilin University (JLU)
      - National Energy Technology Laboratory (NETL)
      - Lawrence Livermore National Laboratory (LLNL)
  - IGHCCS2 Benchmark Problem 2
    - Review of submitted solutions
      - GEOMAR
      - University of California Berkeley (UCB)
      - Pacific Northwest National Laboratory (PNNL)

The study teleconferences were principally focused on code descriptions and establishing initial benchmark problems. All teleconferences were recorded and those recordings were posted on the NETL EDX system, along with the slide decks from the presentations. A logo for the study was created based on the infamous burning gas hydrate photo taken by Bill Lawson.

## MILESTONES:

Milestone Title	Milestone Description	Planned Completion Date	Actual Completion Date	Status / Results
Nitrogen Injection (KIGAM-funded, Separate, Coordinated PNNL Project #68908)	Conduct a series of numerical simulations using its STOMP-HYDT-KE simulator to assess the feasibility of the nitrogen injection technology for production natural gas.	6/30/2018	Partially completed	Simulations with STOMP-HYDT-KE against a series of nitrogen injection experiments. Dr. Won Suk Lee visiting PNNL during April to discuss next steps.
Geomechanics Implementation and Verification	Develop algorithms for its STOMP-HYDT-KE simulator for computing the geomechanical properties as a function of hydrate saturation.	3/31/2018	7/4/2018	Verification simulation executed with STOMP-HYDT-KE against the classical Terzaghi problems.
IGHCCS2: Problem Definition	Initial Problem Set Drafted and Participants Identified for the 2nd	9/30/2017	4/26/2018	A series of four benchmark problems have been identified along with problem champions. Problem

	International Hydrate Code Comparison Study.			descriptions being developed and vetted.
IGHCCS2: Problem Issue	Initial Problem Set Issued for the 2nd International Hydrate Code Comparison Study.	12/31/2017	Partially completed	Problem #1 released, and first solution submissions reviewed on April 12, 2018 during the IGHCCS2 teleconference. Problem #2 released and first solution submissions reviewed on May 31, 2018.
IGHCCS2: Problem Submission	Initial Problem Set Submission for the 2nd International Hydrate Code Comparison Study.	6/30/2018	Partially completed	Problem #1 released, and first solution submissions reviewed on April 12, 2018 during the IGHCCS2 teleconference. Problem #2 released and first solution submissions reviewed on May 31, 2018.

**PRODUCTS:**

No publications nor presentations were released this quarter.

**IMPACT:**

No significant impacts occurred this quarter.

**CHANGES/PROBLEMS:**

The IGHCCS2 is progressing with benchmark problems being developed and submissions being review. Participants are joining the regularly scheduled teleconferences, but discussions are minimal.

**SPECIAL REPORTING REQUIREMENTS:**

No special reporting requirements occurred during this quarter.

**BUDGETARY INFORMATION:**

Actual Cost (this quarter)	Actual Cost (cumulative for BP)	Funds available (for the BP)	Balance of unspent funds (for the BP)	Actual Cost (cumulative for the full FWP)	Funds available (for the full FWP)	Balance of unspent funds (for the full FWP)
\$25,596	\$50,686	\$100,000	\$49,314	\$286,962	\$370,000	\$83,038

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