

**Project Title:** Kinetic Parameters for the Exchange of Hydrate Formers

**Award Number:** 65213

**Submitting Official:** Mark D. White, Research Engineer, PNNL

**Project Period:** Begin: 07/01/2013 End: open

**Reporting Period:** Begin: 07/01/2013 End: 09/30/2013

**Report Term:** Quarterly

### **Executive Summary**

Through the funding support of the U.S. Department of Energy under this Field Work Proposal the Pacific Northwest National Laboratory (PNNL) will investigate numerically and experimentally an unconventional technology for producing geologic accumulations of natural gas hydrates. The guest-molecule-exchange technology involves replacing methane molecules with the clathrate structure with alternative guest molecules, such as carbon dioxide and nitrogen. The alternative guest molecules are selected to maintain the original hydrate structure and be thermodynamically preferred under the reservoir temperature and pressure conditions. The numerical component of the proposed work will investigate the Iñik Sikumi Gas Hydrate Field Trial, a collaborative project conducted by the U.S. DOE National Energy Technology Laboratory, ConocoPhillips, and the Japan Oil, Gas, and Metals National Corporation on the Alaska North Slope. The experimental component of the proposed research will provide supporting kinetic exchange data, needed by the numerical simulations. Both the numerical and experimental elements are preliminary investigations due to the limited scope of the proposed work.

### **Goals and Objectives**

This project will investigate the kinetics of exchanging CO<sub>2</sub> and N<sub>2</sub> with clathrated CH<sub>4</sub> in hydrate bearing geologic media. The project comprises two distinct components: 1) numerical investigation of the 2012 Iñik Sikumi gas hydrate field trial, and 2) experimental investigation of kinetic exchange processes in laboratory-scale hydrate bearing unconsolidated sands. The principal objective of the numerical component will be to provide an interpretation of the data gathered at Iñik Sikumi Well #1. The experiment component of this project is designed to provide kinetic exchange parameters needed in the numerical simulation. The principal objective of the two experiments is to provide an order of magnitude value to the kinetic exchange parameters for the field-scale simulations of the Iñik Sikumi gas hydrate field trial.

## **Technical Highlights, Results and Discussion**

This project comprises three distinct tasks; one numerical simulation and two experimental. Work on all tasks will begin in the next quarter. An encouraging development in the understanding of the guest-molecule exchange process is the publication of the recent paper by Lee et al. (2013); where their research provide evidence that CH<sub>4</sub> hydrate transitions to mixed CH<sub>4</sub> + CO<sub>2</sub> hydrate without significant hydrate dissociation.

### *Ignik Sikumi History Match*

The paper proposal for the 2014 Offshore Technology Conference, entitled "Guest Molecule Exchange Kinetics for the 2012 Ignik Sikumi Gas Hydrate Field Trial," was accepted. Otherwise there is no progress to report, as work on the project was delayed until the start of FY14.

### *CH<sub>4</sub>-CO<sub>2</sub>-N<sub>2</sub> Exchange Study*

There is no progress to report, as work on the project was delayed until the start of FY14.

### *Pressurized X-Ray Diffraction Study*

There is no progress to report, as work on the project was delayed until the start of FY14.

## **Risk Analysis**

As both the numerical and experimental work on the project was delayed to the start of FY14, the risks associated with this project are those described in the Project Management Plan.

## **Schedule/Milestone Status**

### *Ignik Sikumi History Match*

Title: Review archived data and previous simulation attempts.  
Planned Date: 9/30/2013

The planned date for this numerical simulation task will be moved to 12/31/2013, to be accordance with the delay in starting the work.

## **Cost Status**

This quarter concluded with a cost variance of about \$32.5k, mostly due to project staff being occupied with other project work. The cost status spreadsheet is shown on the following page.

### **Conclusion**

The start of this project was delayed to allow for completion of other FY13 projects, giving researchers a block of time to start the project.

### **References**

Lee, S. Y. Lee, J. Lee, H. Lee, and Y. Seo. 2013. "Experimental Verification of Methane – Carbon Dioxide Replacement in Natural Gas Hydrates Using a Differential Scanning Calorimeter." *Environmental Science and Technology*, accepted for publication.

Baseline Reporting Quarter	FY2013 Start: 10/01/2012 End: 09/30/2013				FY2014 Start: 10/01/2013 End: 09/30/2014			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Baseline Cost Plan								
Task 1.0					\$12,500	\$12,500	\$12,500	\$12,500
Task 2.0					\$11,250	\$11,250	\$11,250	\$11,250
Task 3.0					\$10,000	\$10,000	\$0	\$0
Task 4.0					\$10,000	\$10,000	\$0	\$0
Non-Federal Share								
Total Planned Cost (Federal and Non-Federal)					\$32,500	\$32,500	\$12,500	\$12,500
Cumulative Baseline Cost					\$32,500	\$65,000	\$77,500	\$90,000
Actual Incurred Costs								
Task 1.0					\$0			
Task 2.0					\$0			
Task 3.0					\$0			
Task 4.0					\$0			
Non-Federal Share								
Total Planned Cost (Federal and Non-Federal)					\$0			
Cumulative Baseline Cost Variance					\$0			
Task 1.0					\$12,500			
Task 2.0					\$11,250			
Task 3.0					\$10,000			
Task 4.0					\$10,000			
Non-Federal Share					\$0			
Total Planned Cost (Federal and Non-Federal)					\$32,500			
Cumulative Baseline Cost					\$0			

Task	Milestone Descriptions	FY2013 Start: 10/01/2012 End: 09/30/2013				FY2014 Start: 10/01/2013 End: 09/30/2014				Planned Start Date	Planned End Date	Actual Start Date	Actual End Date	Comments
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4					
Task 2	Review archived data									7/1/13	9/30/13	10/28/13		
Task 2	Submitte Iqmk Shuman field trial									10/1/13	12/31/13			
Task 2	Compare simulation results									1/1/14	3/31/14			
Task 2	Report interpretations									4/1/14	6/30/14			
Task 3	Conduct Kinetic Exchange Exp.									10/1/13	12/31/13			
Task 4	Conduct Hydraulic Structure Exp.									10/1/13	12/31/13			