

**Award No. DE-FC26-05NT42666  
Battelle Pacific Northwest Division**

**Gas Hydrates Assessment  
B. Peter McGrail, Principal Investigator**

**Quarterly Report – Q2 (FY2007)**

**Executive Summary**

This project will compare and contrast, through numerical simulation, conventional and innovative approaches to producing methane from gas hydrate-bearing geologic reservoirs. Initially, the project will investigate the production of gas hydrates from idealized reservoir configurations. If the initial investigation shows promise for the innovative approaches, additional simulation studies will be conducted using actual gas hydrate reservoir data from the Alaska North Slope (ANS) region. The project completed the initial planning phase this quarter with issuance of a comprehensive Research Management Plan and Statement of Project Objectives. A Technology Status Assessment Report was also completed and submitted to the NETL COR.

**Results of Work During Reporting Period**

*Phase I*

Task 1: Project Management

B. Peter McGrail traveled to Hyderabad, India in January to participate in a Workshop on R&D Needs for CO<sub>2</sub> Capture and Sequestration Technologies, including discussions on gas hydrate production concepts utilizing CO<sub>2</sub>. This trip was funded in its entirety Battelle.

Task 2: Technology Status Assessment

The summary report describing the current state of gas hydrate production technology was finalized and submitted. The principal conclusions from this report are that thermal stimulation suffers from poor recovery efficiencies, depressurization is currently the most economical technology, but is rate limited by the self-regulating thermal nature of gas hydrates, and gas exchange (including EHGR) appears promising but its success or failure will depend on the results of future scientific research and thorough modeling studies of reservoir production performance.

Task 3: Basic reservoir Simulation

Task 3.1: Reservoir Simulations, Sub-Task 3.1.1: Algorithm Review, Verification and Establish Baseline Methane Hydrate Reservoir Simulation Parameters

At the start of the fiscal year, the STOMP-HYD simulator had capabilities for simulating the production of gas hydrates using thermal stimulation and depressurization, with completed

capabilities for gas exchange. This subtask had the objectives of improving simulation performance, implement inhibitor capabilities, complete and verify gas exchange capabilities, and investigate alternative code formulations.

Simulation times and convergence rates have significantly improved since the start of this project. The most important change to the code was the conversion of the hydrate saturation calculations from a pressure differential basis to a temperature difference basis. This conversion has not altered the simulation results, but has decreased simulation times by reducing Newton-Raphson iterations and increasing time-step size. The natural gas hydrate system can involve six pore-space phases (i.e., aqueous, liquid CO<sub>2</sub>, gas, hydrate, ice, precipitated salt) and four components (i.e., water, CH<sub>4</sub>, CO<sub>2</sub>, inhibitor). With this complexity, it is not always apparent which numerical formulation will yield the best performance. As with the seemingly subtle change between a pressure and temperature differencing, occasionally simulation performance can be improved through alternative approaches. Inhibitor capabilities in the simulator have been realized through a recently published expression for the shift in the temperature-pressure equilibrium curve for gas hydrates with an inhibitor. These efforts along with results of code comparison activities underway on another project give high confidence that appropriate baseline parameters for methane hydrate reservoir simulation parameters have been established in STOMP-HYD.

#### Task 4: Reservoir Simulation with ANS Field Data

This task is not scheduled to start until Task 3 scope has been completed.

#### **Significant Issues and Corrective Action**

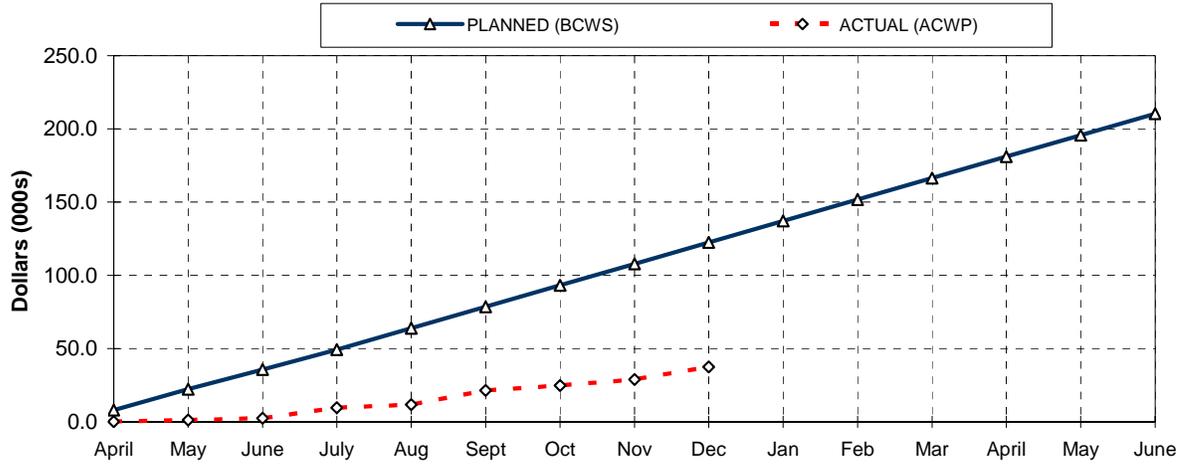
Initiation of Task 2 and Task 3 work was delayed due to more extensive modification and revisions to the RMP than expected. Senior staff have also had very limited time available due to other project commitments. This situation has significantly improved. Our spending rate is expected to ramp up significantly in Q3 of FY07.

Contract negotiations between Battelle and the Korea Institute of Geoscience and Mineral Resources (KIGAM) are nearing completion. KIGAM will participate in the Task 3 activities on this project through use of the STOMP-HYD code.

#### **References**

White, M. D. and B. P. McGrail. 2006. " STOMP-HYD: A New Numerical Simulator for Analysis of Methane Hydrate Production from Geologic Formations," In Proceedings of 2nd International Symposium on Gas Hydrate Technology, 1-2 November 2006, KIGAM, Daejeon, Korea.

Planned and Actual Cumulative Spending Curve  
(DOLLARS IN THOUSANDS)



(\$K)	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June	FY07
<b>Planned Cost</b>	7.97	14.33	13.37	13.7	14.64	14.64	14.6	14.6	14.64	14.6	14.64	14.6	14.6	14.6	14.64	210.4
<b>Actual Cost by Month</b>	0.2	1.1	1.2	7.1	2.2	9.7	3.2	4.3	8.5	1.4	13.2	5.1				57.2
<b>Variance Cost</b>	7.7	13.2	12.2	6.6	12.5	4.9	11.4	10.4	6.1	13.3	1.5	9.5				
<b>Cumulative Planned</b>	8.0	22.3	35.7	49.4	64.0	78.6	93.3	107.9	122.6	137.2	151.8	166.5	181.1	195.8	210.4	210.4
<b>Cumulative Actual</b>	0.2	1.3	2.5	9.6	11.8	21.5	24.7	29.0	37.5	38.9	52.0	57.2				
<b>Cumulative Variance</b>	7.7	21.0	33.1	39.7	52.2	57.1	68.5	78.9	85.0	98.3	99.8	109.3				

Milestones	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	April	May	June
Task 1. Prepare a Research Development Plan					☆										
Task 2. Prepare a technology Status Assessment												☆			
Project Kickoff Meeting				☆											
Complete Research Management Plan						☆									
Quarterly Reports			☆			☆			☆			☆			△

LEGEND	SCHEDULED	△	DEVIATION	□	COMPLETED	☆
	TIME LINE	—	⊗			