



## **Extraction of natural gas from subsea gas hydrate deposits coupled with CO<sub>2</sub> storage – Modeling and simulation**

Georg Janicki, Stefan Schlüter, Torsten Hennig, and Görge Deerberg

Fraunhofer UMSICHT, Process Technology, Oberhausen, Germany (georg.janicki@umsicht.fhg.de, +49 208 8598 1295)

Natural gas hydrates found worldwide in subsea sediments are of rising economical and ecological interest. The vast amount of carbon assumed in gas hydrate deposits can help to overcome a shortage of fossil energy resources in the future. To increase their potential for energy applications today new technological approaches for the extraction of natural gas from gas hydrate deposits are being discussed and developed.

The incineration of hydrate based natural gas can contribute to the energy supply but the coupled CO<sub>2</sub> emission causes climate change effects. To develop a sustainable hydrate based energy supply system the sequestration of CO<sub>2</sub> has to be coupled with the CH<sub>4</sub> production from the hydrate deposit. Due to this demand the simultaneous storage of CO<sub>2</sub> in hydrate deposits has to be developed.

From the thermodynamic point of view this process seems to be applicable because CO<sub>2</sub> hydrate is more stable than CH<sub>4</sub> hydrate. Regarding technological implementation many problems have to be overcome. Especially mixing, heat and mass transfer in the reservoir are limiting factors causing very long process times.

Within the scope of the German research project »SUGAR« different technological approaches are evaluated and compared using numerical models for dynamic system simulations and analysis. Therefore, detailed mathematical models for most relevant chemical and physical effects are developed. Basic aspects of gas hydrate formation/destabilisation and mass and heat transport mechanisms are considered and implemented into simulation programs like CMG STARS and UMSICHT-HyReS.

The simulation of the production system consisting of well data and realistic properties of deposits is based on predefined production scenarios as

- Huff'n'Puff - Simultaneous injection and extraction using one well
- two well method - injection via one well and extraction via second well (vertical system, horizontal system - SAGD principle)
- depressurization
- thermal stimulation

Using different parameter sets for geological, thermodynamic and production parameters the storage and production rates are compared to identify promising technologies.