The SUGAR Project

In summer 2008, the SUGAR project (Submarine Gas Hydrate Reservoirs) was launched in Germany. The project aims to produce natural gas from marine methane hydrates and to sequester carbon dioxide (CO_2) from power plants and other industrial sources as CO_2-hydrate in marine sediments. This large-scale national project is funded by two federal ministries and German industries. The total funding is 13 Mio. € over an initial funding period of three years. The project has 30 institutional partners from academia and industries and is coordinated at the Kiel-based Leibniz Institute for Marine Sciences (IFM-GEOMAR).

Production of natural gas

Vast amounts of natural gas (methane) are bound in marine gas hydrates (~3000 Gt of carbon). The carbon content of this natural reservoir is as large as the total inventory of carbon in all known coal, oil, and gas deposits. Natural gas is the most environmental friendly source of fossil energy:

- Neither heavy metals nor flue ash are released into the environment during energy production.
- The emission of CO_2 is reduced by ~50 % when coal is replace by natural gas in power production.
- Gas-steam power plants are used to stabilize power grids because their energy production can be regulated easily without loss in efficiency. With the growing contribution of renewable energies (wind and solar) more of these gas-based power plants are needed to compensate for seasonal and diurnal changes in energy production.

Unfortunately, the current supply of natural gas can not meet the growing demand. Natural gas is produced in only a few regions worldwide (Russia, Caucasus, Persian Gulf, North Sea) and several deposits are increasingly depleted. Many international conflicts such as the current Caucasus crisis are exacerbated in this geopolitical setting.

The development of methane hydrate deposits as future energy resource would greatly rectify this situation. Hydrates are wide-spread along all continental margins at water depth beyond 400 m. To name only a few states, India, China, South Korea, Japan, Brazil, Chile, the US, Canada, Russia, and Norway possess vast hydrate reservoirs within their exclusive economic zones (EEZ). Hydrates do not occur in the shallow marginal seas of the German EEZ. German academia and industries hold, however, rich scientific and technical expertise in the area of hydrate research that will be further developed within the SUGAR project. German industries and academia are seeking international partners to develop their hydrate deposits in a joint effort and to test the new SUGAR technologies in the field.

Environmental risks of hydrate exploitation

The role of marine methane hydrate in the natural environment was thoroughly investigated in a number of large scale projects funded by the German ministry of research and education over the last decade. More than 10 Million € have been spent since 1996 to conduct this research. The results of these projects have been published by SUGAR scientists in a series of articles in major international scientific journals and were seriously considered during the development of the SUGAR project. The basic research showed that:

- rich ecosystems flourish around outcropping methane hydrate deposits at the deep-sea floor;
- continental slope sediments are often cemented and mechanically stabilized by methane hydrates;
- future seafloor warming may induce large-scale hydrate melting leading to slope failure and massive greenhouse gas emissions.

The following measures were taken in the SUGAR project to account for these consolidated findings:

- Outcropping hydrate deposits will not be exploited. Only those deposits that are covered by extensive layers of impermeable fine grained sediments will be developed. These deposits are not colonized and used by benthic fauna. The impermeable sedimentary apron will also inhibit the release of methane into the environment during hydrate mining.
- Hydrates deposited in steep slope areas will not be developed. Hydrates will only be exploited in even terrain and extensive geotechnical surveys will be performed prior to hydrate production to avoid slope failure.
- Exploited methane hydrates will be replaced by CO_2-hydrates. CO_2-hydrates are more stable than methane hydrates and are spontaneous formed when liquid CO_2 is injected into methane hydrate deposits. Sediments are cemented and stabilized by CO_2-hydrate to further reduce the risk of slope failure. In contrast to methane hydrates, CO_2-hydrates will not dissociate upon future seafloor warming. Gas swapping in hydrates will thus help to mitigate future greenhouse gas emissions at the seafloor.

Carbon capture and storage (CCS)

Industrial CO_2 emissions are causing global warming and are severely affecting marine ecosystems. Capture of CO_2 at power plants and storage of CO_2 in geological formations is regarded as one important measure to mitigate anthropogenic CO_2 emissions and global climate change by IPCC, EU and other international organizations. CO_2 is usually stored as supercritical phase in depleted oil and gas reservoirs and deep saline aquifers located on land or below shallow seas. The following potential problems are associated with the current CCS approach:

- Supercritical CO_2 is a mobile, buoyant, and aggressive chemical. Only those reservoir rocks that are covered by thick and impermeable cap rocks can be developed for CO_2 storage. Supercritical CO_2 may nevertheless ascend through bore holes, faults and fractures and may escape into the environment.

- The pore space of deep aquifers is occupied by saline formation water and natural gas. The displacement of these fluids and gases by injected CO_2 may cause strong over-pressures in the reservoir and/or the leakage of brine and gas into the environment.
- There may not be enough storage capacity in saline aquifers and depleted oil and gas reservoirs to accommodate a significant fraction of the global anthropogenic CO_2 production.

The CO_2-storage approach developed within the SUGAR project may greatly help to resolve these problems:

- CO_2 will not be stored as buoyant supercritical fluid but as solid CO_2-hydrate. This approach will greatly mitigate the risk of CO_2-leakage since CO_2 is fixed in the sediment matrix as dense and immobile solid phase.
- Free pore space will be created by the coeval production of natural gas from methane hydrates. The injection of CO_2 into pore space previously filled by methane hydrates will not lead to over-pressurization and leakage of gas and brine.
- The storage capacity of hydrate-bearing marine sediments is almost unlimited.

The current rise in global CO_2 emissions is largely caused by the increasing use of coal as energy resources. The power supply system of the rapidly growing economies of China and India is mainly based on coal. These emerging states also possess vast methane hydrate reservoirs and could use these deposits not only to produce natural gas but also to safely store CO_2 from coal power plants. German SUGAR technologies will be made available to other interested parties and may thus help to mitigate anthropogenic CO_2 emissions not only in Europe but on a global scale.

New technologies to be developed within the SUGAR project

During the first phase of the SUGAR project (July 2008 – June 2011) the following new technologies will be developed for enhanced hydrate exploration, exploitation, and natural gas transport:

- Hydroacoustic, seismic, electromagnetic, and autoclave drilling equipment will be improved and tested in the field to locate new hydrate deposits, to image the three dimensional distribution of hydrates in the sub-surface, and to quantify the methane inventory of hydrate deposits. New software will be developed for the joint inversion of seismic and electromagnetic data. Existing basin models will be expanded to simulate the formation of methane hydrates via gas migration.
- The production of natural gas from methane hydrates via injection of CO_2 will be investigated in laboratory experiments under in-situ conditions. Various approaches will be tested in the lab to accelerate gas swapping in hydrates and to improve the rate of natural gas production from hydrates. These include the addition of other gases (N_2, Ar, etc.) and specially designed polymers, injection of warm surface waters using a mega-pump approach, and the generation of heat by in-situ methane burning in the reservoir. The results of the laboratory experiments will be up-scaled by reservoir modeling to identify the most efficient technologies for methane production and CO_2 storage in hydrates.
- New technologies will be developed to land the natural gas produced at off-shore hydrate deposits. A mobile off-shore factory will be projected to produce methane hydrate pellets. The pellets will be transported ashore at normal pressure and -20°C via new carrier vessels to be designed by SUGAR partners. The SUGAR project aims to further develop the hydrate pellet transport originally introduced by Norwegian and Japanese scientists and industries as an energy efficient alternative to the LNG (liquefied natural gas) approach.

In a second phase, starting in July 2011, hydrate exploitation will be tested in the field together with international cooperation partners.

SUGAR partners

Project	Academia	Industries
A1	IFM-GEOMAR, University of Bremen	L3 Communications ELAC Nautik GmbH
A2	IFM-GEOMAR, BGR Hannover	K.U.M. Umwelt- und Meerestechnik GmbH, Magson GmbH, SEND Offshore GmbH
A3	University of Bremen, TU Clausthal	PRAKLA Bohrtechnik GmbH
A4	IFM-GEOMAR	IES, TEEC
B1	Fraunhofer UMSICHT, GFZ Potsdam, IFM-GEOMAR	Wintershall, Wirth GmbH
B2	FH Kiel, GFZ Potsdam, Fraunhofer UMSICHT, IOW, IFM-GEOMAR	BASF, CONTROS GmbH, R&D Center at FH Kiel, 24sieben Stadtwerke Kiel AG, RWE Dea, Wintershall, E.ON Ruhrgas AG,
B3	IOW, FH Kiel	Linde AG, Aker Yards, Lindenau Schiffswerft, Germanischer Lloyd, BASF

Projects

A1: Hydroacoustic prospection: High-resolution imaging of gas bubbles at the seafloor

A2: Geophysical exploration: Improved seismic and electromagnetic imaging of the three dimensional distribution of hydrates in the subsurface

A3: Autoclave drilling: Ground truthing and robust quantification of hydrate contents

A4: Basin modeling and joint inversion of seismic and electromagnetic data to resolve the spatial distribution of hydrates and to quantify hydrate inventories.

B1: Reservoir modeling to identify the most efficient technologies for hydrate exploitation and CO_2 storage

B2: Laboratory experiments to optimize natural gas production and CO_2 storage

B3: Improved hydrate pellet technologies for the transport of natural gas

Figures

Structure of the SUGAR project

New SUGAR technologies

CO_2 sequestration

https://ftp.ifm-geomar.de/users/cutecht/SUGAR_figures

Further information (in German)

http://www.ifm-geomar.de/index.php?id=sugar

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