



 NTNU
 SINTEF

Gas Technology Activities 2009

Report by the
Gas Technology Centre
NTNU-SINTEF

Table of contents:

Preface.....	3
Research news	4
Conferences and workshops	5
New R&D projects	6
Selection of national R&D projects	7
Selection of European R&D projects coordinated by NTNU/SINTEF	9
Other European projects with NTNU/SINTEF participation.....	10
Research groups and networks.....	10
Communication with politicians	11
Education	12
Internal events	13

About the Gas Technology Centre NTNU-SINTEF

The Gas Technology Centre NTNU-SINTEF (GTS) was established in 2003 and is the largest centre for gas technology research and education in Norway. GTS provides new knowledge and technology which will contribute to efficient, environmentally friendly and profitable utilization of natural gas.

The GTS focuses on exploring and exploiting the synergism of multidisciplinary research based on NTNU and SINTEF's broad expertise that encompasses the entire value chain from the energy source to the end user.

Approximately 75 professors/associated professors, 10 adjunct professors, 150 PhD candidates, 25 Post Doc researchers at NTNU and 200 research scientists at SINTEF are associated with GTS.

The mission of GTS is to act as a common interface in gas technology R&D between NTNU/SINTEF and the market.

More specifically, GTS will:

1. Increase the visibility of gas technology R&D at NTNU/SINTEF, both externally and internally.
2. Promote new R&D opportunities and initiatives
3. Influence Norwegian national priorities
4. Ensure top quality education and recruitment of students and researchers
5. Be active in networking and internationalization activities
6. Promote internal coordination and synergism in gas technology R&D at NTNU/SINTEF

CCS - Carbon dioxide Capture and Storage

DNV - Det Norske Veritas

FCH JU - Fuel Cells and Hydrogen Joint Undertaking

FME - Norway's Centres for Environment-friendly Energy Research

GTS - Gas Technology Centre NTNU-SINTEF

IFE - Institute for Energy Technology

LNG - Liquefied Natural Gas

NFR - Research Council of Norway

NTNU - Norwegian University of Science and Technology

SFI - Centre of Research-based Innovation

UiS - University of Stavanger

UiB - University of Bergen



Preface

This report provides an overview of the ongoing activities in gas technology at NTNU and SINTEF, with special focus on the main achievements in 2009. Our R&D includes 8 new projects, 16 national projects and 11 European R&D projects which are all described briefly. On the education front, we are proud of the 26 PhD candidates that have been awarded their doctorates this year in gas technology.

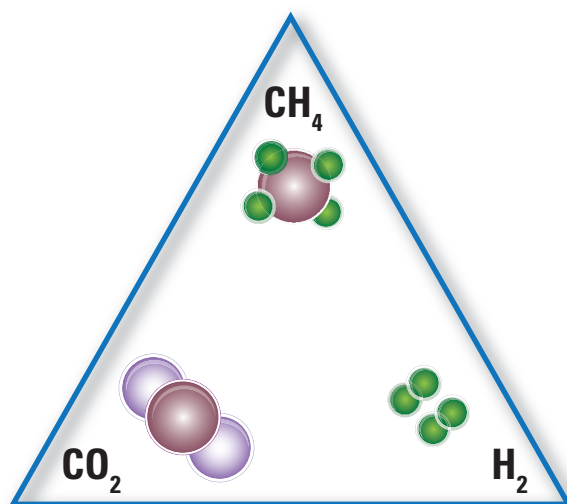
NTNU and SINTEF are very active in environmentally friendly energy research, comprising renewable energy sources, carbon dioxide capture and storage (CCS), and energy conservation. A clear proof of this is the involvement of NTNU and SINTEF in six of the eight Centres for Environment-friendly Energy Research established by the Research Council of Norway in 2009, and coordinating five of them.

NTNU and SINTEF have active in the development of sustainable oil and gas production in Norway for decades. In particular, subsea, gas processing, materials, information and communication technologies are areas where the R&D conducted at NTNU and SINTEF is internationally acknowledged for its high quality.

Further development of natural gas technologies is crucial in the transition towards a sustainable energy system. The use of natural gas presents opportunities for reduced emissions of carbon dioxide and other gases relative to other fossil fuels. Core competence in processing, conversion and the use of natural gas is also highly relevant in a renewable fuel perspective, such as hydrogen technology and bioenergy.

This report comprises information on R&D activities in gas technology. In our context, the term gas technology refers to several gases: methane, carbon dioxide and hydrogen, as illustrated in the figure, and involves numerous scientific disciplines. It covers the entire gas value chain from the source to the end user.

This report has been prepared by the Gas Technology Centre NTNU-SINTEF.



Research news

H₂S laboratory

A laboratory has been established for the testing of sorbents for sour gases, like CO₂ and H₂S, and for the evaluation of H₂- and O₂- selective membranes in the presence of H₂S under realistic process conditions. The construction has been supported by SINTEF Materials and Chemistry, the EU-CAESAR project, and the FME-BIGCCS centre.

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CorLab

CorLab is a tailor-made laboratory complex for materials testing and science, comprising of seawater corrosion laboratory, H₂S and chloride induced stress corrosion cracking laboratory, general electrochemistry laboratory, wear and tribology laboratory, climate chamber and auto-clave systems certified for up to 300 bar and 200°C.

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LH₂ lab

A plant for liquefaction of hydrogen (LH₂) has been built in a SINTEF Energy Research laboratory as part of the NFR project "Efficient hydrogen liquefaction processes" sponsored by Shell Hydrogen. The plant was built with focus on investigating novel concepts of hydrogen pre-cooling down to about 80K by use of mixed refrigerant processes.

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NyFrakt - New Freight vessels for Norwegian coastal operation

Development of LNG-fuelled ship concepts for Norwegian coastal operation. New efficient ship designs have been demonstrated in model tests at MARINTEK. Project supported by MAROFF (NFR), Association of Cargo Freighters, Ship Owners, Charterers, Equipment Industry, Møre-forskning Molde and MARINTEK.

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LNGshipping - Decision support in LNG supply chains

A prototype for operational planning in LNG business (LNGscheduler) was delivered in June. The model is expected to significantly increase profitability in LNG value chains. The tool can simultaneously handle contract obligations, ship routing and inventory management, and all major physical limitations related to LNG logistics, both upstream and downstream. The project is supported by MAROFF (NFR), Statoil and GDF Suez.

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Demonstration of forklift truck with hydrogen and fuel cells

In June a hydrogen powered forklift truck was demonstrated in Trondheim. A lower cost fuel cell capable of operating at sub-zero temperatures was developed in the NORPEM project, supported by Nordic Energy Research and coordinated by SINTEF. Project partners; Power Cell, Volvo Technology, Statoil and H2Logic.



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High pressure synthesis

Synthesis of methanol, dimethyl ether and Fischer-Tropsch products in microchannel reactors at high pressure (80 bar) was demonstrated at NTNU/SINTEF, in collaboration with Karlsruhe Institute of Technology. The project is supported by GTS, PETROMAKS and GASSMAKS programmes (NFR) with the partners Statoil, UOP, Bayerngas Norge, Aker Solutions and Det Norske Veritas, as well as the inGAP project.

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Recognition Award to DYNAMIS

The President of SINTEF Energy Research Sverre Aam received the "CSLF Recognition Award" on behalf of the European FP6 project DYNAMIS under the Carbon Sequestration Leadership Forum's (CSLF) ministerial meeting in London in October. "DYNAMIS has successfully assessed various alternatives for large-scale hydrogen generation, incorporating CCS in collaboration with many companies and organisations throughout Europe," said Terje Riis-Johansen, the Norwegian Minister of Petroleum and Energy, who presented the award.



www.dynamis-hypogen.com

CryoLAB - Cryogenic laboratories

SINTEF Energy Research has decided to fund CryoLAB. The 15 MNOK investment during two years will provide unique support for LNG research at SINTEF and NTNU. The establishment of CryoLAB is supported by NTNU, which is a partner.

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Conferences and workshops

European Conference on CCS Research, Development and Demonstration

The conference was arranged under the auspices of the Decarbit project coordinated by SINTEF, and took place 10-11 February in Oslo. It had 220 participants from 16 ongoing projects in the 6th and 7th European Framework Programmes with focus on CCS research and technological development.

www.ccs-conference.com

The Gassmaks conference

The conference took place in Trondheim 27-28 May with 120 participants. It was arranged by SINTEF together with NFR and NTNU, and focused on new possibilities for increased industrial processing and refining of natural gas in Norway.

www.sintef.no/Projectweb/Gassmaks-konferansen2009

The 5th Trondheim Conference on CO₂ Capture, Transport and Storage, TCCS-5

TCCS-5 was organized by GTS in collaboration with the BIGCO₂ project and took place 16-17 June in Trondheim with 300 participants from 24 countries. There were 100 oral presentations, and a poster session with more than 50 contributions. Sponsors: Statoil and CLIMIT (NFR).



www.ntnu.no/tccs5

Hydrogen workshop

During the EVS24 symposium in Stavanger 12-15 May, a Hydrogen workshop was arranged by SINTEF as part of the NorWays-project. The Minister for Transportation and Communications, Liv Signe Navarsete, listened to key messages from representatives from U.S. Department of Energy, the European Director for General Motors as well as internationally leading R&D institutions. The main message was that we need biofuels, electricity as well as hydrogen to reach our ambitious emission reduction goals in the transport sector.



www.ntnu.no/norways

International Workshop on "Non-Equilibrium Thermodynamics"

The workshop was organized by NTNU, SINTEF and IFE and took place in Trondheim 3-4 September with 40 participants. Sponsors: Delft Physical Chemistry Fund, GTS and NTNU.

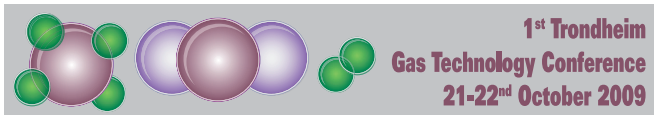
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5



1st Trondheim Gas Technology Conference, TGTC-1



www.sintef.no/Projectweb/Trondheim_GTS/

TGTC-1, arranged by GTS, took place in Trondheim on 21-22 October and had 85 participants. The conference included 38 oral presentations and a poster session with 17 contributions. Sponsors: Gassco, Statoil and NFR.

Nordic Hydrogen conference

The conference was arranged by the Norwegian Hydrogen Forum and took place in Oslo on 24-26 November with almost 100 participants. The conference combined the annual HyNor conference and the Norwegian hydrogen and fuel cell seminar. The objective was to give a comprehensive overview of fuel cell and hydrogen activities in the Nordic countries and strengthen the collaborative network in this field. NTNU, SINTEF, GTS and Statoil were among the sponsors.



www.hydrogen.no/h2conference2009

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Fundamental aspects of CO₂ capture by absorption

The seminar was arranged by NTNU and University of Texas at Austin on 19 June in Trondheim. It had 70 participants.

Advanced Membranes for clean and sustainable processes

The foremost international conference series promoting dialogue between academia and industry on research and the application of membrane technology. The conference was arranged on 7-12 June in Trondheim by the Memfo research group at NTNU. Sponsors: NTNU, SINTEF, Statkraft, Statoil, UOP/Honeywell and Veolia Water Solutions & Technologies.

www.engconfintl.org/9aj.html

New R&D projects

BIGCCS Centre – International CCS Research Centre

The centre is one of the eight FMEs in Norway. It seeks to realize full-scale CO₂ management for power production and industrial processes through long-term, basic research, encompassing the entire CO₂ chain. 26 partners from eight countries. Budget: 45 M€.



www.BIGCCS.no
More on the FMEs:
www.cedren.no
www.cenbio.no
www.nowitech.no
www.forskningsradet.no/energiserter

ECCSEL

- European Carbon dioxide Capture and Storage Laboratory Infrastructure

The mission of ECCSEL is to form a European distributed research infrastructure on CCS to be operational at the end of 2013. The investments needed are estimated to more than 80M€. A proposal for funding a preparatory phase was submitted to the EU 7th Framework Programme in December. The preparatory phase is estimated to start in late 2010.



www.eccsel.org



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iCap – Innovative CO₂ capture.

The iCap project focuses on innovative post-combustion CO₂ capture techniques using chemical absorption media on combined CO₂/SO₂-removal as well as on the utilization of advanced polymeric and ceramic membrane materials. Contract negotiations were conducted in 2009. The consortium has 15 partners comprising of leading European R&D organizations, an industrial group, as well as partners from Australia and China. This is a 4 year project. Budget: 6.6 M€.



Enabling low-emission LNG systems

The project focuses on knowledge and tools for evaluation, operation and design of innovative, environmentally safe, cost-effective and energy-efficient LNG systems. PETROMAKS (NFR). This is a 5 year project. Budget: 43.8 MNOK.

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NEXPEL

The NEXPEL-project was recently acknowledged support from the European Fuel Cell and Hydrogen Joint Undertaking program (FCH JU). The main objective is a successful demonstration of an efficient Proton Exchange Membrane water electrolyser for hydrogen production integrated with renewable energy sources. Coordinated by SINTEF and involves eight European partners. This is a 3 year project. Budget: 26.4 MNOK.

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HyPilot

Preparing for a national pilot test centre for hydrogen technologies. This is a 1.5 year project. Budget: 2 MNOK.

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GassOpt Advanced

Gas quality is the main bottleneck for optimal utilization of the pipeline infrastructure in the North Sea. In November, a new version of GassOptTKL was delivered to Statoil and Gassco, with improved modelling of gas quality, processing plants and compressors. The tool is used for a wide range of transport capacity studies. The project is funded by Statoil and Gassco.

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Techno-economic evaluations of natural gas-based processes

Preliminary evaluations of several natural gas conversion processes under different conditions. Project supported by GASSMAKS (NFR).

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Selection of national R&D projects

BEEDIST - Basic Energy Efficient DISTillation Technology

Design and control of new integrated distillation column configurations. Aiming for energy savings in the range of 20-40%. Supported by GASSMAKS (NFR). Budget: 10 MNOK.

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BIGCO2

CO₂ management technologies for future power generation. The BIGCO2 consortium includes equipment manufacturers, oil and energy companies, research institutes and universities. CLIMIT (NFR). This is a 5 year project. Budget: 16 M€.

www.bigco2.com

BIGCLC

Demonstration of chemical looping technology in natural gas power generation with CO₂ capture. CLIMIT (NFR). This is a 4 year project. Budget: 12 M€.

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BigLNG - Commercial LNG-fuelled cargo vessels

Development of new types of LNG-fuelled cargo vessels. The outcome of the BigLNG project is two LNG-fuelled RoRo ships currently under construction for operation along the Norwegian coast and in the North Sea.

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Enabling production of Remote Gas

The project address the critical technology barriers related to floating production of natural gas from smaller fields. Partners: Statoil, UOP, Bayerngas Norge, Aker Solutions and DNV. PETROMAKS (NFR). This is a 5 years project. Budget: 40 MNOK.

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Efficient Hydrogen Liquefaction Processes

Improving energy efficiency for liquefaction. RENERGI (NFR). This is a 5 year project. Budget: 11 MNOK.

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GassMat - Integration models for industrial clusters producing materials and energy

The project assesses the potential for environmentally justifiable utilization and industrial processing of natural gas, together with deposits of ore/minerals in the Barents/Northern Region. It considers the establishment of gas-based industrial clusters producing materials and CCS implementation. Partners: Statoil, LKAB, Celsa, Fesil, Alstom, NTNU, SINTEF, GASSMAKS (NFR).

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HiPGLS - High Pressure Gas-Liquid Separation

The project will enhance our understanding of the chemical and physical processes associated with high pressure gas/liquid separation in systems containing hydrocarbons, water and chemicals. Partners: ConocoPhillips Norge, Statoil, Shell Technology Norway, ExxonMobil, VetcoGrey, FMC Kongsberg Subsea, Sulzer Chemtech, Natco Norway, Pall Europe, Peerless, PETROMAKS (NFR).

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inGAP - Innovative Natural Gas Processes and Products

inGAP is a Centre of Research-based Innovation (SFI), appointed by NFR. inGAP is headed by the University of Oslo with SINTEF, NTNU, Borealis, Statoil, Ineos and Haldor Topsoe as active partners. This is a 5 - 8 year project.

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CCERT - PhD programme in CO₂ Capture, Enabling Research and Technologies

The programme will create knowledge and provide a theoretical basis for the development and design of substantially improved process technologies for CO₂ capture. Budget: 16 MNOK. Project funded by: Statoil, Shell TN, Metso Power Oy, DNV, CLIMIT (NFR).

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LNG Shipping - Decision Support in LNG Supply Chains

The LNG value chain is a network of different planning elements and options which have to be synchronized to achieve optimal resource utilization. Cooperation between Statoil, GDF Suez and SINTEF. Sponsors: MAROFF (NFR) and industrial partners. This is a 4 year project.

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RAMONA

The main objective of this project is to develop new theory, methods and tools to optimize the security of supply and capacity utilization in offshore gas production, processing and transportation systems. Project partners: SINTEF, NTNU, UiS, UiB, CognIT, Gassco and Statoil. This is a 5 year project. Budget: 30 MNOK.

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SFI centre on Integrated Operations (IO centre)

The centre works on gas value chain optimization and integrated modeling, which will result in a multifield asset integrated optimization benchmark consisting of two gas-condensate reservoirs, an oil reservoir and a downstream LNG plant recovery system. The benchmark will be used to evaluate life-cycle production strategies and to assess the business value of value chain optimization.

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www.ntnu.no/iocenter/research/
program2



SOLVIT

Cost-effective technology for post-combustion CO₂ capture. Phase I of the project is ongoing, and focuses on testing alternative amine solvents. The programme includes the construction of a new pilot plant for absorption technology with a full-scale high tower in Trondheim. Partners: Aker Clean Carbon, SINTEF and NTNU. Sponsors: Gassnova, NFR, Scottish Power, E.ON and Statkraft. This is a 8 year project. Budget: 317 MNOK.

www.sintef.no/co2capture

NorWays

The project will provide decision support for the introduction of hydrogen as an energy carrier in the Norwegian energy system. Supported by NFR. This is a 3 year project. Budget: 7 MNOK.


www.ntnu.no/norways

FlareCheck - Flare systems overpressure protection

A series of industrial projects where the reliability of overpressure protection of flare systems is validated through a combination of simulations and reliability calculations. Applied at Kårstø, Kollsnes and Mongstad processing plants in conjunction with several plant extension projects.

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Selection of European R&D projects coordinated by NTNU/SINTEF

DECARBit - Enabling advanced pre-combustion technologies and plants

Development of pre-combustion capture technologies and novel capture technologies. The aim is to achieve a CO₂ capture cost of 15€/tCO₂. The project also includes plans for pilot testing.


<http://www.decarbit.com>

ECCO - European value chain for CO₂

The main objective is to identify how CCS can become economically viable. It includes establishing recommendations for how a European infrastructure for CCS could be built, and identifying how CCS value chains could be established.


www.sintef.no/ecco

DYNAMIS - Towards hydrogen and electricity production with CO₂ management

Development of concepts for electricity and hydrogen production with CCS, and establishment of a basis for a demonstration plant (the Hypogen plant).


www.dynamis-hypogen.com

SUSPLAN - Integration of renewable energy into the European energy system

Development of regional and European-wide guidelines for more efficient integration of renewable energy into future infrastructures. SUSPLAN will simultaneously assess future scenarios for electricity, heating and gas infrastructure developments.


www.susplan.eu

RECCO2 - Recovery of CO₂ from high pressure natural gas

The objective is CO₂ removal from high pressure natural gas streams using a polymeric blend membrane. The project includes material development, pilot construction, durability tests and simulations. Project led by the MEMFO research group at NTNU with the industrial partner Statoil. Funded by GASSMAKS (NFR).

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Other European projects with NTNU/SINTEF participation



www.co2cesar.eu

CESAR – CO₂ Enhanced Separation and Recovery

Development of low cost post-combustion CO₂ capture technology towards economically feasible solutions for both new power plants and retrofitting existing plants. The primary objective is to decrease the cost of capture down to 15 €/tCO₂.

www.co2remove.eu

CO2ReMove - Geological storage of CO₂

Monitoring and verification techniques for deep subsurface CO₂ storage.



www.co2-coach.com

COACH – CCS cooperation with China

CCS demonstration plant in China, including options for coal-based electric power generation and production of hydrogen.



www.naturalhy.net

NATURALHY

Testing of critical components of a hydrogen system by adding hydrogen to natural gas in existing networks.

COCATE

The objective is to analyse the conditions for pooling of CO₂ capture and transportation systems from smaller CO₂-emitting industrial facilities. Partners: IFP, Le Havre Region Development Agency, Geogreen, Accoat, SINTEF Energy Research, DNV, TNO, Port of Rotterdam NV and SANERI. This is a 3 year project. Budget: 4.5 M€.

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NanoGLOWA - Nano materials against global warming

NanoGLOWA brings together universities, power plant operators, industry and SMEs in order to develop optimal nanostructured membranes and installations for CO₂ capture from power plants. The MEMFO research group at NTNU is a major partner. Funded by the EU 6th Framework Programme. This is a 5 year project.

www.nanoglowa.com

Research groups and networks

The MEMFO Research Group

The MEMFO group at the Department of Chemical Engineering NTNU has been active since 1994. It focuses on membrane gas separation and liquid separation.

www.chemeng.ntnu.no/memfo

KinCat – The Petrochemistry and Catalysis Gemini Centre at NTNU/SINTEF

Research and teaching in catalysis and petrochemistry, including surface science, adsorption and physical studies of porous materials, reaction kinetics and process engineering.

www.chemeng.ntnu.no/research/kincat

FCH-JU - Fuel Cells and Hydrogen Joint Undertaking

FCH JU is a public-private partnership supporting research, technological development and demonstration (RTD) activities in fuel cell and hydrogen technologies in Europe. Its aim is to accelerate the market introduction of these technologies, realizing their potential as an instrument in achieving a carbon-lean energy system.



ec.europa.eu/research/fch



N.ERGHY - New European Research Grouping for HYdrogen

N.ERGHY represents around 60 R&D institutions in Europe with a total of more than 2000 researchers working in the field of hydrogen and fuel cells. SINTEF is represented in the Executive Board of N.ERGHY, chairing the Application Area Transportation and Refuelling Infrastructure. N.ERGHY is one of the three members of FCH JU, along with the European Commission and the Industrial Grouping.



research on fuel cells & hydrogen

www.nerghy.eu

CO2NET

CO2NET is a Carbon Dioxide Knowledge Sharing Network, which was initially set up under the EU 5th Framework Programme. It is now an industry-led, self-funded network and comprises more than 30 major companies and organizations in Europe, USA and Australia extensively involved in the development of CCS.



www.co2net.com

Communication with politicians

Dialogue meetings on the future of oil and gas R&D

During the autumn, GTS has had meetings with the following Norwegian politicians: Erna Solberg and Linda Helleland from Høyre (Conservative), Gunn Karin Gjøl from Arbeiderpartiet (Labour) and Tord Lien from FrP (Progressive) to discuss the future of oil, gas and CCS research. It was communicated that oil and gas research must be strengthened to assure value creation and environmentally sound exploitation of fossil energy resources in the future. The meetings included visits to the Multiphase Laboratories and the CO₂ Laboratory, both at Tiller. They were mutually experienced as highly valuable and the dialogue will be followed up.



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European Economic Area Joint Parliamentary Committee Meeting

On 29 October, SINTEF with large support from GTS hosted the European Economic Area Joint Parliamentary Committee Meeting on the topic: "The EU's energy and climate policy; research on CCS and offshore wind technology". Around 45 participants from the European Free Trade Association (EFTA), the European Commission and Stortinget (Norwegian parliament) took part in the one day programme.



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Anbefalinger til de politiske partiene foran
Stortingsvalget 2009 fra SINTEF og NTNU

En helhetlig satsning på klima og energi



NTNU
SINTEF

Climate change and energy recommendation from NTNU and SINTEF

The document called "En helhetlig satsning på klima og energi" was delivered by Unni Steinsmo, President SINTEF, and Torbjørn Digernes, Rector NTNU, to the political parties in August. It contained recommendations for climate change and energy policies, and greenhouse gas abatement measures. CCS was recommended as one of the key technologies for combating climate change.

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Gas Technology Activities at NTNU and SINTEF 2009 - Report by the Gas Technology Centre NTNU-SINTEF

11



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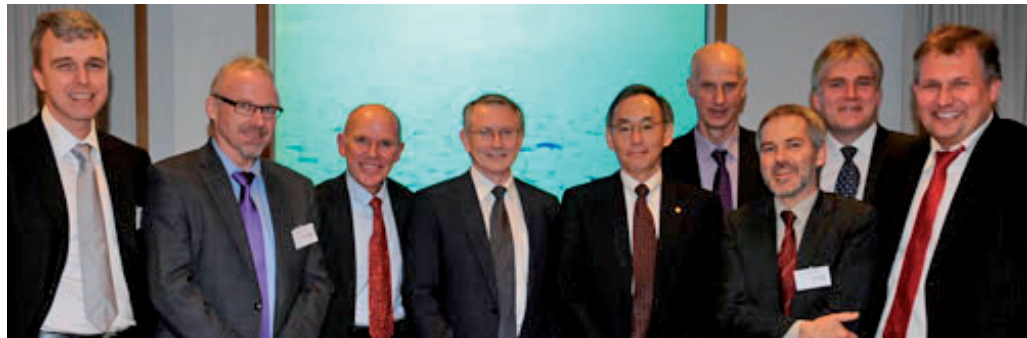
Visit from Finance Minister

Finance Minister Kristin Halvorsen from the Norwegian Socialist Left Party visited SINTEF Energy Research on 9 June. The meeting included presentations in renewable energy, CCS, and the recently established FMEs, and visits to the Thermal Energy, Bioenergy and Wind laboratories.



Meeting with U.S. Secretary of Energy

Steven Chu, U.S. Secretary of Energy, researcher and Nobel laureate, accompanied U.S. President Barack Obama to Oslo for the bestowal of the Nobel Peace Prize. On 11 December, Steven Chu was invited by Norway's Minister of Petroleum and Energy, Terje Riis-Johansen, to meet with Norwegian energy researchers to discuss climate challenges and to visit some of Norway's most advanced power facilities. Nils Røkke, Erik Lindeberg, Petter Støa, SINTEF and Torgeir Moan, NTNU, gave presentations during the meeting.



From left: Helge Drange, University of Bergen; Torgeir Moan, NTNU; Alf Bjørseth, Scatec; Arvid Hallén, NFR; Steven Chu, U.S. Secretary of Energy; Erik Lindeberg, Petter Støa and Nils Røkke, SINTEF and the Minister of Petroleum and Energy, Terje Riis-Johansen.

www.forskningsradet.no/en/Newsarticle/US+energy+secretary+met+with+Norwegian+energy+researchers/1253953151984



Education

PhD studies in gas technology

The following list summarizes all PhD candidates in gas technology that have concluded their studies at NTNU in 2009.

Last name	First name	Institute*	Title
Andreassen	Trygve	IKJ	New methods for preparation of optically active unsaturated amines
Aske	Elvira Marie	IKP	Design of plant wide control systems with focus on maximizing throughput
Andresen	Trond	EPT	Mathematical Modeling of CO ₂ based Heat Pumping Systems - New Developments for Simulation Tools to Aid the Design of Systems for Non-residential Buildings
Barri	Mustafa Ali Mustafa	EPT	Turbulent Shear Flows Subject to System Rotation
Bruun	Kristine	IMT	Bond Graph Modelling of Fuel Cells for Marine Power Plants
Colombo	Konrad Werner Eichhorn	EPT	Mixed-Conducting Membrane-based Gas Turbine Power Plant for CO ₂ Capture
Deng	Liyuan	IKP	Development of Novel PVAm/PVA Blend FSC Membrane for CO ₂ Capture
Hartono	Ardi	IKP	Characterization of diethylenetriamine (DETA) as absorbent for Carbon Dioxide
Kim	Inna	IKP	Heat of reaction and VLE of post combustion CO ₂ absorbents
Knuutila	Hanna	IKP	Carbon dioxide capture with carbonate systems
Kristiansen	Trygve	IMT	Two-Dimensional Numerical and Experimental Studies of Piston-Mode Resonance
Korsvik	Jarl Eirik	IMT	Heuristic Methods for Ship Routing and Scheduling
Lervik Mejdell	Astrid	IKP	Properties and application of 1-5 µm Pd/Ag23wt.% membranes for hydrogen separation
Linhart	Andreas	IKP	An aggregation model reduction method for one-dimensional distributed systems
Magnussen	Pia	EPT	Investigation into Structure and Behaviour of Laminar and Turbulent Flames by Planar Laser-Induced Fluorescence Measurements
Maråk	Knut Arild	EPT	Condensation Heat Transfer and Pressure Drop for Methane and Binary Methane in Small Channels
Sændru	Marius	IKP	Development of an FSC membrane for selective CO ₂ capture
Schütz	Peter	IØT	Managing Uncertainty and Flexibility in Supply Chain Optimization
Sergeevich Glavatskiy	Kirill	IKJ	Multicomponent evaporation and condensation as described by the square gradient model
Skogvold	Silje	IKJ	Development and properties of nontoxic solid electrodes for environmental surveillance
Smedstad Foss	Martin	IKP	The Effect of Oil on Carbon Dioxide Corrosion Inhibition on Carbon Steel - Potential for Improved Corrosion Protection
Stokke Burheim	Odne	IKJ	Thermal Signature and Thermal Conductivities in PEM Fuel Cells
Strupstad	Andre	IPT	Pressure Loss in Natural Gas Pipelines Experimental Studies of Gas-Particle Flow, Wall Roughness and Drag Reduction
Xu	Jing	IKJ	Transport phenomena in a temperature gradient studied by NEMD. A chemical reaction and a phase transition
Zhao	He	EPT	An Experimental Investigation of Liquid Droplets Impinging Vertically on a Deep Liquid Pool
Zhu	Zhengjie	IKP	The Least-Squares Spectral Element Method Solution of the Gas-Liquid Multi-fluid Model Coupled with the Population Balance Equation

* EPT - Department of Energy and Process Engineering, IPT - Department of Petroleum Engineering and Applied Geophysics, IKJ - Department of Chemistry, IKP - Department of Chemical Engineering, IMT - Department of Marine Technology, IØT - Department of Industrial Economics and Technology Management





International master's programmes

The GTS has been involved in the development of two international master's programmes; MSc in Natural Gas Technology and MSc in Innovative Sustainable Energy Engineering. The programmes are hosted by the Department of Energy and Process Engineering. Eight students started their MSc in Natural Gas Technology in August 2009.

Contact: Olav.Bolland@ntnu.no
www.ntnu.no/studies/msc-natural-gas-technology
www.ntnu.no/studies/msisee



Photo: Serkan Eren
 Contact: Eva.Lien@ntnu.no

Energy from the North – Student excursion to Hammerfest

In September, GTS in cooperation with Statoil organized a student excursion to Hammerfest where Statoil's new plant for natural gas liquefaction was recently commissioned. Twelve master's students from different engineering programmes at NTNU participated in the 5 day programme. Among the topics were: health, safety and environment (HSE), interactive safety course, LNG plant with field course and training simulator, heat exchangers, LNG cooling processes, thermal power generation, gas purification technology, working processes and maintenance planning and rotating equipment.



www.energicampus.no

ECN - EnergiCampus Nord

EnergiCampus Nord is the result of cooperation between NTNU, the University of Tromsø, the University of Stavanger, and the University Colleges of Finnmark and Narvik, to create a research-based educational programme in Energy Engineering in Hammerfest. Budget 2009: 8 MNOK.

Internal events

DNV-NTNU workshop on the Cost of Power, Renewables and Fossil Fuels with CCS

The workshop was organized by GTS and DNV, and involved DNV, SINTEF and NTNU communities. It took place on 27 August in Trondheim and had 60 participants. Topics were the state-of-art on the cost of power for renewable technologies and fossil fuel technologies with CCS, and the basics for CCS cost calculations.



www.dnv.no
www.ntnu.no/gass

Technical seminar series arranged by GTS

- *Scaling-up Carbon Dioxide Capture and Storage (CCS) - from Megatonnes to Gigatonnes*, Howard Herzog, Massachusetts Institute of Technology, 12 March
- *GassMat: Integration models for Industrial Clusters Producing Materials and Energy*, Jack Ødegård, SINTEF Material & Chemistry, 2 April
- *Acid Gas Removal: Problem Description and Experiences from Sleipner Field*, Even Solbraa, Statoil, 28 April
- *The route from fundamental knowledge to problem solving: example from LNG research*, Mona Mølnvik, SINTEF Energy Research, 6 May
- *World Energy Consumption and Resources: an Outlook for the Rest of the Century and the Role of Research in Thermodynamics*, Gian Paolo Beretta, University of Brescia, 3 November
- *Catalytic conversion of biomass to liquid fuels*, Hilde J. Venvik, Department of Chemical Engineering, NTNU, 8 December

www.ntnu.no/gass/seminars





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