NTNU
SINTEF

Annual Report 2012

Gas Technology Centre NTNU-SINTEF

Strategic partner: Statoil

Preface

Maria Barrio

Hilde J. Venvik

Dear reader,
Another interesting year has passed in the world of natural gas. In forecasts (International Energy Agency, and more), natural gas remains key in securing energy supply and mitigating emissions in the coming 20-30 years. This is the case even under tight emissions targets (e.g. limiting the global increase in temperature to 2°C), due to replacement of coal as well as taking the role of complement source together with variable renewable energies. Carbon capture and storage (CCS) as a mitigation option is, however, the only technology on the horizon today that would allow industrial sectors (such as iron and steel, cement and natural gas processing) to meet deep emissions reduction goals. Although still costly, some CO_2 capture technologies are commercially available today and can be applied across different sectors, but storage issues remain to be resolved.

The natural gas market has seen dramatic changes over recent years, due to the technical development that enabled exploration of shale gas in the US. IEA has estimated that unconventional gas may meet more than 40% of the increase global demand for gas by the year 2035. Currently, large variations in the price of gas worldwide are seen, with a weaker link between the gas and the oil price. Increased global capacity as well as technological progress in LNG is expected to even out some of the variations. The development in shale gas has also caused greenhouse gas emissions to decrease in some areas, but increase in other areas, depending on the gas vs. coal price. The relatively large "wet" fraction from the shale gas has had a positive effect on the US economy, which went from polymer importer to polymer exporter. The development has also resulted in several new plans for gas-to-liquids (GTL) operations, and extremely good profits in existing operations.

In conclusion, the developments described above may point to a "golden age of gas" coming up, but with uncertainties in the market and considerable challenges with respect to emissions. Hence, competence and technological development in all parts of the natural gas value chain is more important than ever to ensure efficient and profitable as well as environmentally friendly natural gas utilization. The research and education at NTNU and SINTEF is well positioned and prepared to take on this mission, and GTS works to develop and display this potential.

GTS was proud to announce the completion and publishing of Energy Procedia Volume 26 on 18th of August 2012, containing the proceedings from the 2nd Trondheim Gas Technology Conference Preparations for the 3rd Trondheim Gas Technology Conference have just started, and the first call for the conference will soon be ready.

In our "Education" strategy, one main effort was the student excursion to the Statoil Tjeldbergodden Methanol plant in. 31 students from NTNU applied for the 12 available seats to train at one of the world's most efficient methanol plants, and we received highly positive feedbacks from Statoil and the students after the visit. We are also proud to report on considerable scientific output from the PhD candidates supported by GTS.

The Gas Technology Centre (GTS) organization saw some changes during 2012. Research Director Duncan Akporiaye replaced Research Director Ole Wærnes in the GTS the Board, representing SINTEF Materials and Chemistry. In addition Dr. Eleni Patanou was appointed as coordinator, replacing Torstein G. Skarsgard. Dr. Maria Barrio completed her 5-year term of office as SINTEF's director of the centre at the end of December. From 1st of January 2013, Astrid Lilliestråle will serve as SINTEF manager of GTS. Dr. Steffen Møller-Holst's 4-year engagement as leader of GTS' hydrogen initiative also came to an end in December 2012. All contributors are thanked for their hard work and inspiring contributions.

The 5-year contract on GTS between the partners expired on 31st of December 2012. The GTS board and management team therefore put considerable effort into outlining the future strategy in dialog with the partners, and in view of the global developments described above. Within 2013 a renewed strategy and financial basis for GTS for the period 2013-17 should have come in place. The main principles of the strategy are outlined at the end of this report.

Finally, we want to thank Statoil, NTNU and SINTEF for their support to the GTS, without which our work would not be possible.

Maria Barrio and Hilde J. Venvik
Co-directors of the Gas Technology Centre NTNU-SINTEF

The Gas Technology Centre NTNU-SINTEF

The Gas Technology Centre NTNU-SINTEF (GTS) was established in 2003. Being the largest centre for gas technology research and education in Norway, GTS acts as a common interface in gas technology R&D between NTNU/SINTEF and the market.

The GTS facilitates new knowledge and technology for efficient, environmentally friendly and profitable utilization of natural gas. The synergism of multidisciplinary research based on NTNU and SINTEF's broad knowledge base is utilized, encompassing the entire value chain from the energy source to the end user.

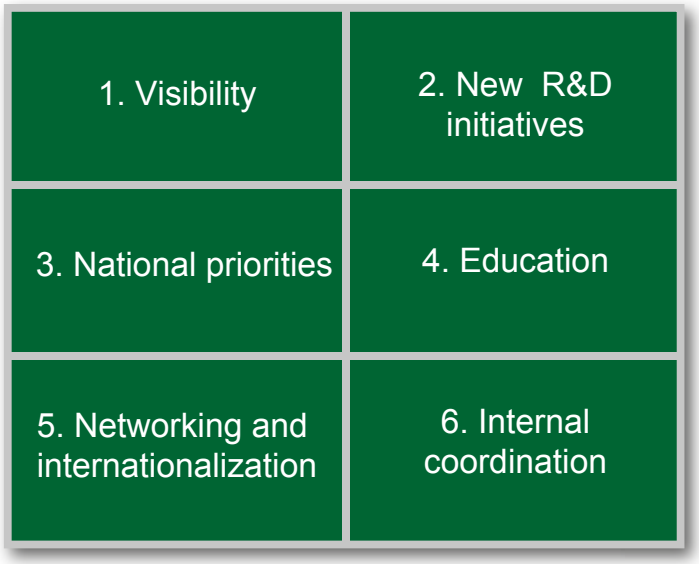
More specifically, GTS will:

1. Increase the visibility of gas technology R&D at NTNU/SINTEF.
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

Main achievements in 2012

- Proceedings from the 2nd Trondheim Gas Technology Conference
- Student Excursion to Tjeldbergodden
- Strategy and continued funding for GTS 2013-17

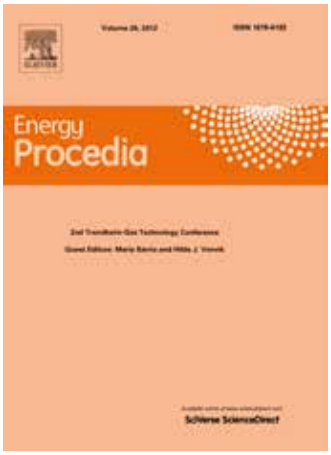
GTS Strategy



GTS	Gas Technology Centre NTNU-SINTEF
NTNU	Norwegian University of Science and Technology
NFR	Research Council of Norway
LNG	Liquefied Natural Gas
CCS	Carbon dioxide Capture and Storage
N.ERGHY	New European Research Grouping on Fuel Cells and Hydrogen

Activities in 2012

1. Visibility



2nd Trondheim Gas Technology Conference (TGTC-2011)
The proceedings from the 2nd Trondheim Gas Technology Conference were published in Elsevier, Energy Procedia, Volume 26, pages 1-134 (2012).

www.sintef.no/Projectweb/GTS/News--Media

Barents Sea Conference 2012
Professor Hilde Venvik, co-director of the GTS, held a presentation entitled *Hvordan kan ressursene i nord best utnyttes? (How can the Arctic resources best be exploited?)* during the session "Gas and industry" at the Barents Sea Conference 2012 on 25th of April. The presentation gave an overview on the challenges and opportunities associated with industrial natural gas conversion. In addition GTS participated at the BarentsExpo with a roll-up presenting GTS and the opportunities for education and gas research at SINTEF and NTNU.

BarentsSea Conference
BarentsSea Exhibition

www.barentshavkonferansen.no/barents-sea-conference/

GTS roll-up in BarentsExpo

Technoport 2012 – Sharing Possibilities Conference

GTS co-director Maria Barrio represented GTS at the Technoport Conference in Trondheim on 16th of April. She was invited to present on *Natural gas as a transition technology* as a part of the session on Transition technologies-CCS, focusing on barriers and opportunities for innovation and implementation of CCS technologies. Moreover, GTS supported the organization of a Public Drive in Trondheim, featuring 4 fuel cell electric vehicles which for the first time were made available for test drives from the public.

http://2012.technoport.no/

6th International Workshop on Non-equilibrium Thermodynamics/ 3rd International Onsager Symposium

GTS supported Prof. Signe Kjelstrup to organise the workshop that was held in Røros Hotel on 19-24th of August, 2012. There were 42 talks and 13 posters, and each day contained a discussion session. The workshop brought together researchers of different backgrounds to unify a variety of approaches in a common generalized theory suited for application on the nanoscale. The participants had the chance to widen their own views on the possibilities and present limitations of non-equilibrium thermodynamics on the nanoscale level.

www.complexfluids.ethz.ch/cgi-bin/CONF/g

Contribution to Fuel Cells and Hydrogen Joint Undertaking (FCH JU) and N.ERGHY

The Brokerage Event for the 2012-call of the FCH JU-program was arranged in Brussels February 9th with around 100 participants. N.ERGHY's 10th General Assembly took place November 27nd, followed by the Review Days for FCH JU on 28th and 29th November, both in Brussels. GTS contributed to preparations and chairing sessions at these events, through Steffen Møller-Holst's role as Chair for Application Area Transportation and Refuelling Infrastructure. These represent the key annual events in Europe within hydrogen technology and demonstration.

www.fch-ju.eu

2. New R&D opportunities and initiatives

The role of GTS is to support the development of new projects and initiatives, with special focus on topics requiring close cooperation between different scientific expertise and groups within NTNU and SINTEF.

GTS has supported participation from SINTEF in the EERA Shale Gas working group:
The efforts in 2012 resulted in a recommendation to the Executive Committee of EERA from the working group *on the establishment of a Joint Program on Shale Gas to ensure a common and independent EU knowledge and competence base to draw on for politicians and decision makers.*

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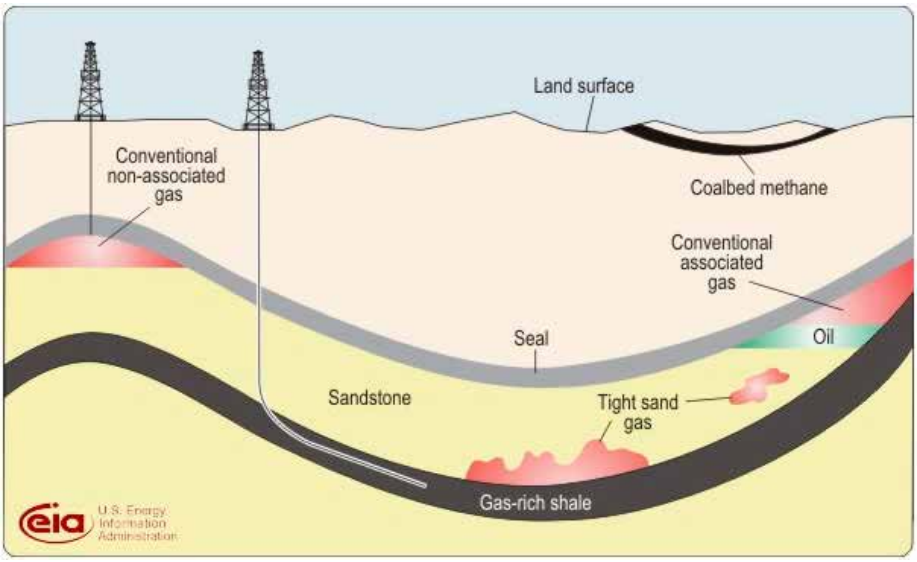


Geology of natural gas resources
Source: U.S. Energy Information Administration (April 2010)

GTS has supported activities and initiatives within small scale LNG:

- The establishment of new contacts and licensees for the Mini-LNG application developed by SINTEF for reliquefaction of boil-off gas from an IM Skaugen multigas carrier. The cost and energy efficiency challenges have been overcome by using standard equipment and construction in steel frames for low investment cost and fast manufacture a modular liquefaction unit, a mixed refrigerant (N_2,C_1,C_2,C_3,C_4) refrigeration cycle with for low energy demand, combined with adaptation of selected equipment and operational conditions to the given application and NG composition
- Participation in the Small Scale LNG 2012 conference that took place in Oslo, May 29-30, hosted by TEKNA. The conference aims to give an update on the LNG business and technology, as well as instruments to meet environmental requirements, and brings together technology developers and the gas industry with shipping, classification, finance and insurance businesses.

Contact: Petter.Neksa@sintef.no

GTS supported two initiatives focusing on energy efficiency:

- NTNU: Collaboration between the Department of Energy and Process Engineering, NTNU, and Politecnico de Milano on energy efficient gas technology for energy production in off-shore installations.
- SINTEF: Dissemination of results and continued efforts within the R&D project EFFORT
- Biogas separation: GTS supported a successful research funding application to the Research Council of Norway (ENERGIX program) from SINTEF together with the company MemfoACT. MemfoACT is a young company based in Trondheim, Norway which produces carbon membranes for biogas separation. The project aims to improve the sealing technology for hollow fiber carbon membrane modules, thereby allowing for operation at higher temperature (100°C - 350°C) that will enable new separations and will greatly extend the market applications for carbon membranes.

www.sintef.no/Effort/

Contact lars.nord@ntnu.no

Gas-to-liquids (GTL):
Recent development in the natural gas market has increased the profitability of GTL projects. Compact GTL technology is also emerging as a potential technology for environmentally friendly utilization of associated gas as well as for biomass conversion. GTS was therefore involved in several new national and international initiatives, as well as research applications, utilizing the high competence in this area between the GTS partners.

Contacts: Hilde.J.Venvik@ntnu.no, Torbjørn.Gjervan@sintef.no

Gas-to-metallurgy:
Hilde Venvik served on the steering committee of the "Use of Natural Gas in Metal production (NatGasMetal)" an internal strategic project at SINTEF Materials and Chemistry that seeks to understand the potential and challenges involved in developing new processes for production of metals using natural gas.

Contacts: Halvor.Dalaker@sintef.no, Leiv.Kolbeinsen@ntnu.no

GTS supported the development of initiatives within CO_2 storage such as:

- Joint drilling programme, aiming at the development of methods for CO_2 appraisal scientific drilling. appraisal scientific drilling
- CO_2 pilot site cooperation with Ketzin (Germany).
- EU initiative MIRECOL towards Mitigation and remediation of undesired leakage of CO_2.
- CO_2 for Enhanced Oil Recovery (EOR)

Through its H_2 initiative, GTS has supported and facilitated the establishment two new projects supported by the Fuel Cells and Hydrogen Joint Undertaking (FCH JU) program:

- SmartCat; Efficient catalysts for automotive fuel cells, SINTEF Materials & Chemistry
- Sapphire; Control and prognostics for increased life of PEMFCs, SINTEF IKT

In addition, three more initiatives were submitted for the 2013-call:

- MegaStack; Stack design for MW-scale PEM-electrolysers, SINTEF Materials & Chemistry
- PuriPhy; Gas quality assurance, SINTEF Materials & Chemistry
- High volume bipolar plate manufacturing, SINTEF Materials & Chemistry

Contact:
Steffen.Moller-Holst@sintef.no

3. National priorities

PETROMAKS 2 programme plan

PETROMAKS 2 is a Large-scale Programme within the Research Council of Norway that begun in 2012 while PETROMAKS (2003-2012) was under finalization, and will be in full operation from 2013. PETROMAKS 2 will promote knowledge creation and industrial development to enhance value creation for society by ensuring the development and optimal management of Norwegian petroleum resources within an environmentally sustainable framework.

An extensive process was carried out to make sure the Programme plan responds to the needs of the industry and the research community. GTS has participated actively in several of the technology target areas (TTA) to promote the role for gas and a visible position of gas technology research in PETROMAKS 2.

www.og21.org

energi 21

www.forskningsradet.no/prognett-petromaks2/Home_page/1253980921309

Energiforskningskonferansen 2012

Arne Bredesen and Hilde Venvik participated at Energiforskningskonferansen 2012, hosted by the Research Council of Norway. The conference addressed the international perspective in energy research. In addition, sessions were arranged to provide input to the new, 10-year research program – ENERGIX. This Research Council of Norway large-scale programme for energy research started in the second half of 2012, and Hilde Venvik was appointed to serve at the program board.

The Research Council of Norway

www.forskningsradet.no/prognett-energix/Home_page/1253980140022

NTVA Technology Forum 2012

The Norwegian Academy of Technological Sciences (NTVA) hosted its Technology Forum on 6th of September on the topic "Natural gas and the Norwegian Industry". Minister of Petroleum and Energy Ola Borten Moe gave the opening address, and was followed by presenters from industry, governmental institutions, research institutes as well as the academia. GTS supported participation from NTNU and SINTEF senior researchers to engage in the discussions.

NTVA is an independent organization founded in 1955 with the objective of promoting research and education in technology and related sciences in order to benefit Norwegian society and industry.

www.ntva.no

Seminar GTS og CenSES 13. juni 2012

CenSES (the Centre for Sustainable Energy Studies – a Centre for Environment-friendly Energy Research (FME) appointed by the Research Council of Norway) and GTS has agreed to collaborate on studies on natural gas. In particular, two directions for further concretization of the cooperation have been identified: Firstly, the application of natural gas for balancing renewable power and, secondly, on the effects of substituting fossil fuels by natural gas in different sectors in a Norwegian as well as European perspective.

CenSES
Centre for Sustainable Energy Studies

www.ntnu.no/censes

4. Education

Student excursion to Statoil Tjeldbergodden

This year's student excursion was organized by GTS in cooperation with Statoil to the Statoil Methanol plant located at Tjeldbergodden. 12 students were selected out of 31 applicants to travel there and follow an educational program held during 1-5 October. GTS received positive feedbacks from Statoil and the students, adding extra value to the existing network between industry and academia.

www.sintef.no/Projectweb/GTS/Education

GTS coordinator E. Patanou and students in uniforms after the walk at Tjeldbergodden plant.
Photo: Mayukh Bandopadhyay

PhD candidates and Post doctoral fellows

Most of the doctoral and post-doctoral research is affiliated with larger research projects or on-going activities within established research groups and centres. Some of these projects have been initiated or supported by GTS.

GTS currently fully finances 2 PhD fellowships:

Tom-Gøran Skog

- **Tom-Gøran Skog**, PhD project: *Development of polymeric hollow fiber membranes for removal of CO2 from high-pressure natural gas.*
  Supervisor: Professor May-Britt Hägg, Dept. Chemical Engineering.

List of scientific presentations:

1. T.G. Skog, M.B. Hägg, *Reinforcement of polymeric hollow fibers with inorganic nanocrystals.* Poster. ICMAT (International conference on materials for advanced technologies), June 26-July 1, 2011, Singapore
2. T.G. Skog, M.B. Hägg, *Increasing the mechanical strenght of Polysulfone hollow fibers with nanocrystals.* Poster. TCCS 6 (Trondheim conference on CO_2 capture, transport and storage), June 14-16, 2011 Trondheim

3. T.G. Skog, M.B. Hägg, *Reinforcement of polymeric hollow fibers with nanocrystals for natural gas sweetening*. Poster. 2nd TGCT(Trondheim gas technology conference), 2-3 November, Trondheim
4. T.G. Skog, M.B. Hägg, *Curved Polysulfone hollow fiber for natural gas sweetening*. Poster. Euromembrane, 23rd-27th September 2012, London

- **Andreas Helland Lillebø**, PhD project: *Conversion of synthesis gas from biomass to liquid fuels by the Fischer-Tropsch synthesis.*
  Supervisor: Professor Anders Holmen, co-supervisor: Professor Edd A. Blekkan, Dept. Chemical Engineering.

Andreas Helland Lillebø

List of scientific publications:

1. A.H. Lillebø, A. Holmen, B.C. Enger, E.A. Blekkan, F*ischer-Tropsch conversion of biomass derived synthesis gas to liquid fuels*, Wires Energy and Environment (2013) in press.
2. J. Zhu, J. Yang, A.H. Lillebø, Y. Zhu, Y. Yu, A. Holmen, D. Chen, *Enhanced stability of Cobalt/Carbon Nanofiber-Carbon Felt Composites in Fischer-Tropsch Synthesis by Coating Silica layer*, (2013) accepted in Catalysis Today.
3. A.H. Lillebø, S. Håvik, E.A. Blekkan, A. Holmen, *Fischer-Tropsch Synthesis on SiC-supported Cobalt Catalysts*, (2012) accepted in Topics in Catalysis.
4. A.H. Lillebø, E. Patanou, J. Yang, E.A. Blekkan, A. Holmen, *The effect of alkali and alkaline earth elements on cobalt based Fischer-Tropsch catalysts*, (2012) accepted in Catalysis Today.
5. C.M. Balonek, A.H. Lillebø, S. Rane, E. Rytter, L.D. Schmidt, A. Holmen, *Effect of Alkali Metal Impurities on Co–Re Catalysts for Fischer–Tropsch Synthesis from Biomass-Derived Syngas*, Catalysis Letters (2010) 138:8-13.

List of scientific presentations:

1. A.H. Lillebø, C. Balonek, E. Rytter, E.A. Blekkan, A. Holmen: *Effects of Li, Na, K and Ca on Co-based Fischer-Tropsch Catalysts*. Poster. EuropaCat X. August 28 – September 2011, Glasgow, Scotland.
2. A.H. Lillebø, C. Balonek, S. Rane, E. Rytter, E.A. Blekkan, A. Holmen: *Fischer-Tropsch biomass to liquids, effect of Li, Na, K, and Ca on Cobalt catalysts*. Poster. 1st International Congress on Catalysis for Biorefineries (CatBior 2011). October 2-5 2011. Malaga, Spain.
3. E. Blekkan, S. Chytil, A.H. Lillebø, B.C. Enger, A. Holmen: *Biomass to liquid fuels - BTL*. Poster. 2nd Trondheim Gas Technology Conference. November 2-3 2011, Trondheim, Norway.
4. A. H. Lillebø, S. Håvik, E.A. Blekkan, A. Holmen: *SiC as support for Co-based Fischer-Tropsch catalysts*. Poster. 15th Nordic Symposium on Catalysis, June 10-16 2012, Mariehamn, Åland
5. J. Yang, J. Zhu, A.H. Lillebø, D. Chen, A. Holmen: *Effect of interfacial properties of hierarchically structured Co catalysts on Fischer-Tropsch synthesis*. Oral presentation. SynFuel 2012 Symposium, June 29-30 2012, Munich, Germany.
6. A.H. Lillebø, E. Rytter, E. Blekkan, E. Patanou, A. Holmen: *Effect of Alkali on Co-based Fischer-Tropsch Catalysts*. Oral presentation. SynFuel 2012 Symposium, June 29-30 2012, Munich, Germany.

GTS is also providing a complimentary scholarship to:

- Luis Castillo, PhD project: *Multi-objective optimization of LNG processes*. Development of a consensual decision-making model based on game theory for LNG processes. Supervisor: Professor Carlos A. Dorao, Dept. Energy and Process Engineering.

List of scientific publications:

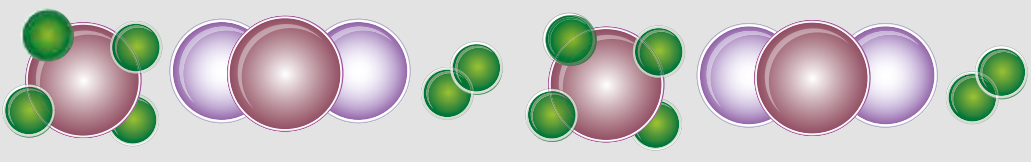
1. Castillo, L. and Dorao, C.A. (2012). *Consensual decision-making model based on game theory for LNG processes*. Energy Conversion and Management 64, pp.387-396.
2. Castillo, L. and Dorao, C.A. (2010). *Influence of the plot area in an economical analysis for selecting small scale LNG technologies for remote gas production*. Journal of Natural Gas Science and Engineering, 2, pp.302-309.
3. Castillo, L. and Dorao, C.A. (2013). *Conceptual Design of pre-cooling stage of LNG plants using propane or an ethane/propane mixture*. Energy Conversion and Management, 65, pp.140-146.
4. Castillo, L., Majzoub M., Di Scipio S. and Dorao, C.A. (2013). *Conceptual analysis of the precooling stage for LNG processes*. Energy Conversion and Management, 66, pp.41-47.
5. Castillo, L. and Dorao, C.A. (2013). *Decision-making in the oil and gas projects based on game theory: Conceptual process design*. Energy Conversion and Management, 66, pp.48-55.
6. Castillo, L. and Dorao C.A. *Decision making on LNG projects*. Enfoque Empresarial-AVPG. June, 2012 (In Spanish)
7. Castillo, L. and Dorao, C.A. (2010). *Methodology for the selection of small scale LNG technologies for remote gas production*. In proceeding of the AIChE Annual Meeting. Salt Lake City, Utah, USA. |ISBN 978-0-8169-1065-6|.
8. Castillo, L. and Dorao, C.A. (2011). *Decision-making on the liquefied natural gas (LNG) projects using game theory*. In proceeding of the IEEE Symposium on Computational Intelligence in Multicriteria Decision-Making. Paris, France. |ISBN: 978-1-61284-067-3|.
9. Castillo, L. and Dorao, C.A. (2011). *Evaluation and selection of the precooling stage for LNG processes*. 23rd IIR International Congress of Refrigeration. Prague, Czech Republic. Paper ID: 542.

List of scientific presentations:

1. Castillo, L. and Dorao, C.A. *The game of making decisions on LNG projects*. Oral presentation. In Proceeding XX International Gas Convection. June 11, 2012. Caracas, Venezuela.
2. Castillo, L. and Dorao, C.A. *A new approach for the selection of small scale LNG technologies for remote gas production*. Oral presentation. 4th International Conference on Small Scale LNG. May 26-27, 2011. Oslo, Norway.
3. Castillo, L. and Dorao, C.A. *Evaluation and selection of the pre-cooling stage for LNG processes*. Oral presentation. 23rd IIR International Congress of Refrigeration. August 21-26, 2011. Prague, Czech Republic.
4. Castillo, L. and Dorao, C.A. *Decision-Making on the Liquefied Natural Gas (LNG) projects using game theory*. Poster. In proceeding of the IEEE Symposium on Computational Intelligence in Multicriteria Decision-Making. April 11, 2011.

Professorship

GTS is funding the position of Adjunct Professor in LNG technology held by Dr. Geir Owren. The position is affiliated with the Department of Energy and Process Engineering, NTNU. Geir Owren is Senior Advisor at the Statoil Research Centre, in the field of gas processing and LNG.



5. Networking and internationalization

MIT collaboration
GTS supported a 6 month research sabbatical to the group of Professor Paul Barton at Massachusetts Institute of Technology (MIT) by Professor Truls Gundersen, Department of Energy and Process Engineering, NTNU This laid the foundation for continued collaboration between MIT, NTNU and Statoil on offshore wind technology and process/LNG optimization.

Visit to Qatar Gas Processing Center
GTS manager Professor Hilde Venvik visited the Gas Processing Center (GPC) in Doha, Qatar, during October 7-9. GPC addresses the problems, challenges, and opportunities facing the state of Qatar's gas processing industry, with focus on the two main themes Asset Management/ Process Optimization and Sustainable Development. The meetings with GPC Director Prof. Abdelwahab Aroussi and staff were oriented toward the potential for collaborations, involving also the experiences from on-going collaborations between NTNU and Qatar within materials technology.

Gas Processing Center
http://gpc.qu.edu.qa/

Polytechnic University of Bucharest, Romania
NTNU received a delegation from Polytechnic University of Bucharest on 2012-06-04 to discuss Erasmus Mundus programmes and EEA grants. They visited GTS as well as the Dept. of Energy and Process Engineering with selected labs, Center for Sustainable Energy Studies (CenSES), the Zero Emmissions Building (ZEB) centre, Dept. of Engineering Cybernetics, NTNU NanoLab and SINTEF Materials and Chemistry. GTS was represented by with the membrane technology and absorption laboratories at the Dept. of Chemical Engineering, NTNU.

11th International Conference on Greenhouse Gas Control Technologies (GHGT-11) Japan.
As part of the support to CO_2 storage initiatives, Maria Barrio participated at GHGT-11 that took place in Kyoto in 18-22 November 2012. NTNU and SINTEF were represented by a visible delegation; 23 oral presentations (out of 297) and 47 posters (out of 623).

www.ghgt.info/index.php/Content-GHGT11/ghgt-11-overview.html

Kyoto International Conference Center
Photo: Svend Tollak Munkejord/SINTEF

Joint Research Centre with Tsinghua University, Beijing, China

The NTNU Thematic Strategic Area Energy hosted a delegation from Tsinghua University on 3rd of October, discussing the establishment of a Joint Research Centre between TU and NTNU on the topics carbon capture and storage (CCS), energy systems and policy, hydrogen technologies, and bioenergy/-fuels. Several representatives from the NTNU-SINTEF gas community participated, including GTS management. Negotiations proceed in 2013.

Visit from North Dakota

In June 2012, a delegation from North Dakota was hosted by the Norwegian Ministry of Petroleum and Energy, industrial companies Statoil and Borregaard, and a number of academic, research and non-governmental organizations. The delegation consisted of top government and local government officials, legislators, executives from the engineering, electric power, and bioenergy sectors, representatives of universities and research institutions, conservation advocates and the media. A Norwegian delegation was then invited to pay a visit to North Dakota in November 2012. The visits initiated exchange of information and ideas on policy and technology best practices in fields of mutual interest, e.g. oil and gas production, long-term management and investment of oil and gas revenue, CCS and CO_2-EOR, advanced biofuels, bio-chemicals and bio-products. Public and private research partnerships and faculty and student exchanges in energy-related fields were discussed.

World Premier International Institute for Carbon Neutral Energy Research, I²CNER

Contact: Vigdis.Olden@sintef.no

The World Premier International Institute I²CNER, represented by Prof. Petros Sofronis, Prof. Naotoshi. Nakashima, and Prof. Mark Paster, visited SINTEF Materials and Chemistry and NTNU on 15.-16. November 2012. GTS and the NTNU-SINTEF gas community presented activities within CCS and fuel cells and hydrogen. A MoU on future collaboration between I²CNER and NTNU/SINTEF is under preparation. An open seminar on I²CNER research was also arranged:

Prof. P. Sofronis:	Hydrogen induced degradation
Prof. N. Nakashima:	Recent findings on catalysis for fuel cells
Prof. Mark Paster:	Carbon-neutral energy pathways for Japan

Prof. N. Nakashima
Photo: Vigdis Olden/SINTEF

Prof. P. Sofronis, Photo: Vigdis Olden/SINTEF

6. Internal coordination

The NTNU thematic strategic areas (TSA) expire in 2013, and the NTNU Board and the Rector's Management Team have initiated a process to identify the strategic areas for the next 10-year period. GTS has participated actively in the development of "Energy" as a continued strategic area. The high impact of energy technology and science in our research and education has been emphasized, as well as the need for teamwork, co-ordination, cross-disciplinary approaches and external promotion of NTNU core competencies.

Technical seminar series 2012

CO_2 Storage

Prof. Erik Lindeberg, SINTEF Petroleum Research, 7 March

The Norwegian petrochemical industry - a value creation opportunity for Norwegian Natural Gas

Dr. Steinar Kvisle, INEOS Scandinavia, 21 March

Process synthesis seminar

Jeffrey J. Siirola, USA, 10 September

The seminars were attended by 30-50 scientists and students from NTNU and SINTEF as well as representatives from industry working with gas technology R&D.

www.sintef.no/Projectweb/GTS/Seminar-Series

Scientific equipment

The following proposals received funding for scientific equipment. Total budget 500 kNOK.

Name	Scientific equipment	GTS funding (NOK)
Amy Brunsvold, SINTEF Energi	Additional equipment to investigate droplet deposition on the shell side of LNG heat exchangers	144 000
Idar Akervoll, SINTEF Petroleum Research	Back-pressure valve for accurate control of the CO2 permeability of low-permeable rocks	135 000
Lars Nord, Department of Energy and Process Engineering, NTNU	Process simulation software for different combined cycles setups designed for offshore oil- and gas installations	6 000
Halvor Dalaker, SINTEF Materials and Chemistry	FTIR spectrometer for gas measurements in the metal production using CH4	115 000
Karen Marie Hammer, SINTEF Materials and Chemistry	Construction of unit for leakage test of subseabed CO2 storage	100 000

Development of strategic R&D interaction

Cooperation with strategic partner

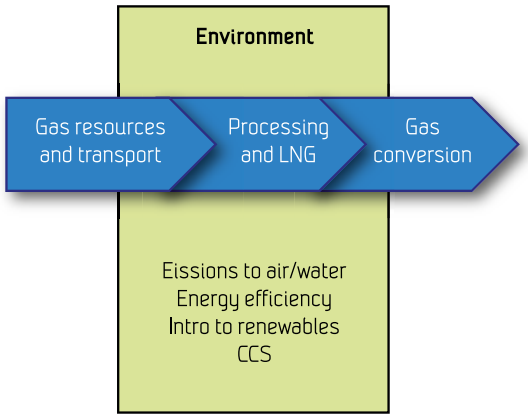
Statoil is an integrated oil and gas company with substantial international activities and is a strategic partner of GTS. The resources from Statoil finance cooperation projects and activities relevant for realizing the New Energy strategy of Statoil. The resources fund PhD and postdoctoral fellowships, laboratory equipment, network building and management of the GTS. During 2004-2009 a full professorship in hydrogen technology was funded by Statoil under the GTS cooperation. The position was held by Professor Hilde J. Venvik, Department of Chemical Engineering, NTNU. The agreement aims to further develop the cooperation between NTNU/ SINTEF and Statoil.

New partners and sponsors

The working period (2008-2012) is coming to an end, and GTS is open for new partners and sponsors to join the strategic R&D interaction for the period 2013-2017 .

GTS 2013-17

The second GTS period came to an end in 2012, and considerable work was put into outlining a strategy for a 3rd period (2013-17), along with securing a continued financial basis between NTNU, SINTEF and the strategic partner Statoil. The new strategy puts the natural gas value chain at the centre, from gas resources and transport to processing and LNG, and eventually to conversion. Associated environmental topics such as emissions, efficiency, carbon capture and storage (CCS) and introduction of renewables also have priority.



- Gas resources and transport
  - Shale gas
  - Biogas, processing and small scale liquefaction
  - European gas infrastructure
  - Integration of gas in energy systems
- Processing and LNG
  - Subsea processing
  - Acid gas removal
  - Northern areas, arctic
  - LNG: centre establishment (research excellence and industrial partnerships).
  - Small-scale and floating LNG
  - Separation, liquefaction and storage of H_2
- Conversion
  - Small-scale and floating (associated gas) GTL
  - Gas to metallurgy
  - Hydrogen production from NG

Innovative and long-term strategy for environmental-friendly gas technology

- Energy efficiency along the value chain
- Synery with renewables
- CCS
- Fuel switch
- Reduction of other emissions
- Societal aspects
- Long term role of gas

GTS in short


Maria Barrio


Hilde J. Venvik


Steffen Møller-Holst


Eleni Patanou


Anita Yttersian

Board of Directors

- Chairman: Director Sverre Aam, SINTEF Energy Research
- Department Manager Gas Conversion Morten Rønnekleiv, Statoil
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- Professor Arne M. Bredesen, NTNU Director of the Strategic Area, Energy and Petroleum – Resources and Environment
- Professor May-Britt Hägg, NTNU Department of Chemical Engineering

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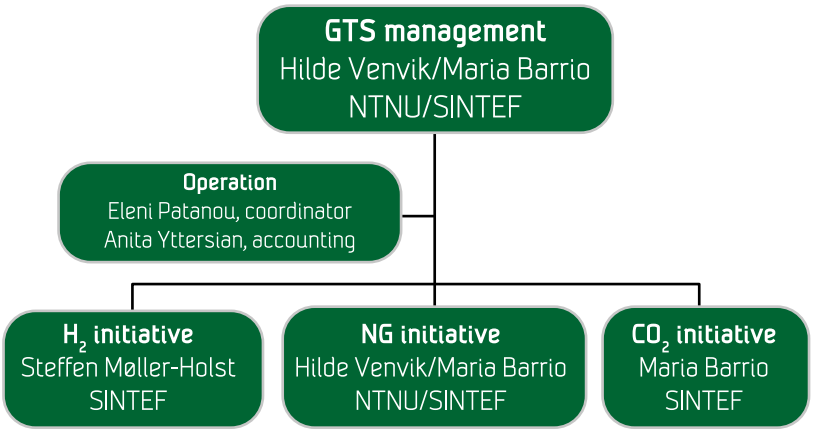
- SINTEF's director of GTS, Vice President, Dr. Maria Barrio
- NTNU's director of GTS, Professor Hilde J. Venvik

Administration

- Co-ordinator, Dr. Eleni Patanou



GTS Organization chart

Staff

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

Norwegian University of Science and Technology (NTNU)

NTNU represents academic eminence in technology and natural sciences as well as in other academic disciplines. Its academic scope ranges from technology, the natural sciences, the social sciences, the humanities, medicine, architecture to fine art. Cross-disciplinary cooperation at NTNU results in innovative and creative solutions.

SINTEF

The SINTEF Group is the largest independent research organization in Scandinavia. SINTEF's goal is to contribute to wealth creation and to the sound, sustainable development of society. SINTEF generates new knowledge and solutions for its clients, based on research and development in technology, medicine, the natural sciences and the social sciences.

NTNU
www.ntnu.no

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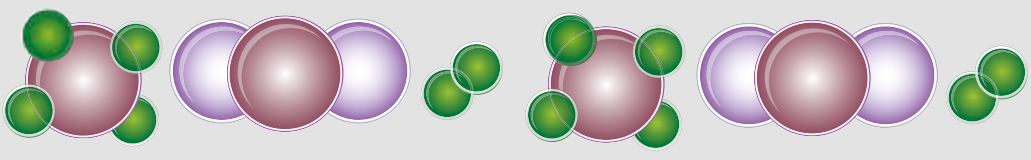

Gas Technology Centre NTNU-SINTEF

NTNU

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Strategic partner: Statoil