

Annual Report 2006

**Strategic Area**  
**Energy and Petroleum**  
**– Resources and Environment**

## What are the Strategic Areas at NTNU?

NTNU wants to be useful to society, by developing and maintaining the national technological skills needed to build a sustainable society. To realize this goal NTNU has given priority to six strategic areas. They aim to facilitate multidisciplinary team-work to result in high-quality research with substantial long-term social impact. The six areas are:

- Energy and Petroleum – Resources and Environment
- Globalization
- Information and Communications Technology (ICT)
- Marine and Maritime Technology
- Materials
- Medical Technology

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- Resources and Environment

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## About Energy and Petroleum – Resources and Environment

Energy is needed to provide for essential human needs like food, housing, clothing, transportation, health and recreation, in short what is needed to live a good life on this planet. By the end of this century, emission of green-house gases needs to be curbed. At the same time around 6 billion new citizens may join in at the global dinner table. How to produce sufficient amounts of clean energy for a future peaceful and sustainable society is today's largest challenge.

There will be a great demand for new knowledge, new technology and new solutions. This is a global challenge which will involve a lot of people in many countries. NTNU, together with SINTEF, want to play an active and productive role to supply the necessary scientific input to the global transformation processes to achieve a sustainable future. The overall goal is to bring forward new knowledge and educate people that may help put the necessary knowledge to use in order to provide clean energy.

A successful transition to clean and sustainable energy systems will depend on global innovation processes. The solutions that will be implemented, has of course to reflect local resources and conditions, but they will emerge from the application of a mixture of key technologies with which NTNU and SINTEF are actively:

- Efficient and sustainable generation, transport and end-user utilization of energy, including oil and gas
- Carbon dioxide capture and storage
- Renewable energy.

Probably, electricity and hydrogen will be the main energy carriers of the future, together with biofuels and biomass. Presently, it is important to bring forward – within the same time frame – a variety of possible technological solutions to allow social choices and local concerns.

Norway may be considered an "energy country". Thus, NTNU and SINTEF have have a substantial energy related activity. Today, more than 750 scientists are involved in the efforts to create a cleaner future. Among them are more than 300 doctoral students and post doctoral researchers doing fundamental energy-related research. At NTNU, more than 250 masters students graduate each year, to supply the energy sector with highly qualified candidates..

Our vision is "**Clean energy for a sustainable society**"

To meet future challenges in a better way, the strategic energy area have adjusted its organization in 2006 to be based primarily on the following six goal-oriented, multi-disciplinary research centres.

- Centre for Smart Energy Efficient Buildings
- Centre for Renewable Energy
- Gas Technology Center
- Centre for Better Resource Utilization
- Centre for Electric Energy and Energy Systems
- Centre for Energy and Society

In addition, there are strategic initiatives that work across the centres:

- CO<sub>2</sub>-Capture and Storage (CCS)
- Hydrogen technology
- Green Innovation
- NanoLab
- TRANSES (Transition to Sustainable Energy System)

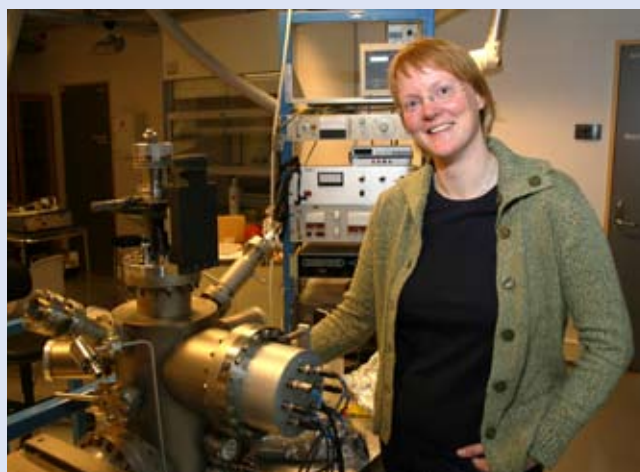
This should make the strategic area well prepared for the hard work that lies ahead.

## Energy and Petroleum – Resources and Environment in 2006

The successful development of the energy area has continued in 2005 and 2006, under the strategic leadership of the Board. The first term of office has now ended and a new Board is under appointment. We are now gaining valuable experience with the multi-disciplinary goal-oriented Centres. They are responsible to develop and implement strategies and action plans within their fields. This means that the energy area is working strategically and systematically throughout its broad and comprehensive field of responsibility. Ongoing research initiated through the area amounts to more than 200 million NOK in external funding. Thus, the annual strategic grant from NTNU of around 2 million NOK seems a good investment.

The main task of the Management and Board is to develop overall goals and strategies and to ensure productive team-work and coordination within the area. Of particular importance is to achieve exchange of knowledge across the area, to promote cross-fertilisation of research. Another challenge which has a lot of attention, is to find better ways of bringing new knowledge forward to innova-

tion and industrial development as well as to policymakers and the general public. This is of course important to the Norwegian society as well as to NTNU and SINTEF. In general, we pursue the strategic idea that activities should emerge through bottom-up processes in the multitude of research teams involved in energy-related research at NTNU and SINTEF. The main role of the strategic area



*The frontier of science. Professor Turid Worren demonstrates laboratory equipment for future high efficiency photovoltaics.*

as such is mainly to coordinate and facilitate bottom-up initiatives in addition to engage in particular high-priority actions. One such high-priority action is internationalisation of energy-related research. The area has put a lot of effort to develop long-term strategic cooperation with selected universities in countries which have been given priority in the national action plans (for details, see separate chapter). We have also prioritised initiatives with respect to EU's Framework programme, with considerable success.

As noted above, most of the activities of the energy area take place within its centres and strategic initiatives. A brief outline is given in the following sections:

### Centre for Smart, Energy-Efficient Buildings (SmartBuild)

The overall aim of the SmartBuild Centre is to develop new knowledge, integrated solutions, and technologies that will make it possible to cover our building-related energy needs with substantially less harmful environmental emissions, while still satisfying the whole range of end-user needs such as comfort, aesthetics, costs, operability, reliability and functionality. The knowledge, technologies, and products developed in this multidisciplinary program will serve as a basis to strengthen education, research, economic growth, and sustainable development of Norwegian industry, community and individuals

#### Research Areas

SmartBuild is organised in three main research areas:

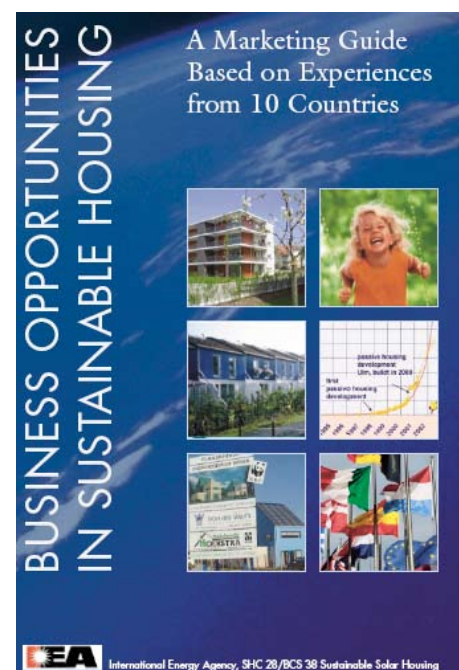
- \* The users and the environment, including user needs, environmental criteria and strategies for the implementation of smart energy efficient solutions

- \* The building, including energy systems integrated in the building and integrated design processes
- \* Energy systems, including daylight systems, photovoltaic systems, heat pump systems, energy storage, and efficient control and automation systems.

#### Some highlights from 2005-2006

In 2005 and 2006, the Smartbygg project has produced 9 papers in international journals with referee, 32 peer-reviewed articles, 2 books, 14 presentations at international conferences, 98 reports and presentations at national conferences and magazines, 5 new concepts/products for energy-efficient buildings and 2 PhDs. At least 5 different private companies have adopted new technologies and knowledge developed in the Smartbygg project.

One of the main events in 2005 was a 2-day seminar with Forsvarsbygg (the Armed Forces construction and property management company).



*New knowledge into practise: energy efficiency in buildings.*



Skilled staff in well equipped laboratories.

### Centre for Electric energy and energy systems NTNU-SINTEF

The political importance of efficient, reliable and environmentally friendly supply of electric energy is steadily increasing. The research centre aims to play an active role in developing technology for production of electric energy from any energy sources. To help achieve this goal, NTNU has in 2006 invested 4 million NOK to establish a "renewable energy laboratory", which facilitates the testing of large generators

and power electronic drives for power grid integration of different distributed energy sources.

In reality, industrial challenges and technological achievements often facilitate new application of electric energy. The need for cheaper and more flexible energy supply equipment for deep water sub-sea oil and gas production is an example. During 2006 the Centre got financial support from the Petromaks KMB program (co-sponsored by NFR and the oil and gas industry) to do three projects within this area. These projects have a total funding of about 65 million NOK over the next 5 years.

In addition, the centre has taken several initiatives towards EU's 7th Framework programme. Preparations for proposals are made regarding the following Energy topics:

- Develop and validate innovative control strategies and network architectures for active networks with large -scale penetration of renewable sources and distributed generation.
- Simulation and estimation of smart electricity transmission networks.
- Electricity network assets management.

In 2006, a total of about 100 researchers and 20 PhD students have been associated with the Gemini centre. They have been publishing actively, both nationally and internationally.

### The Centre for Renewable Energy NTNU-SINTEF-IFE (SFFE)

The Centre for Renewable Energy (SFFE) combines and coordinates the competence at NTNU, SINTEF and Institute for Energy Technology (IFE) within renewable energy. The centre is organised in a virtual way without shared office space. It has a coordinative and consultative function for the teaching and research groups teaming up to promote renewable energy.

In association with Norwegian industry and the Research Council of Norway, SFFE aims to contribute to strategies and knowledge for the innovation and development of new renewable energy technologies. The principal aim of this cooperation is to help save the environment as well as creating economic values.

The centre focuses on the following activities:

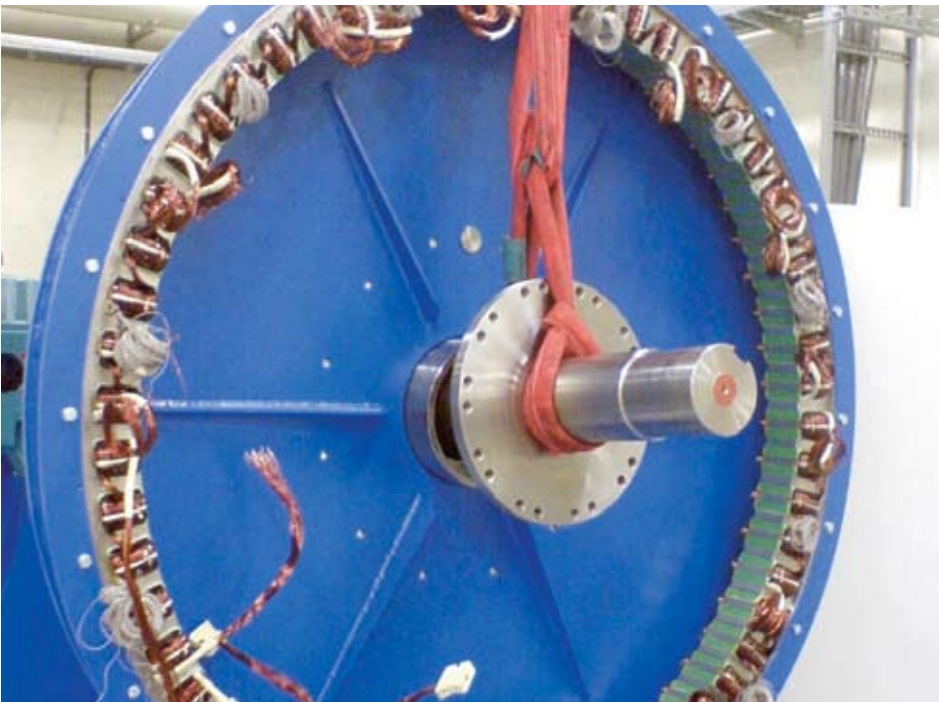
- Promotion and information dissemination of renewable energy related issues, both in media and among partners.
- Initiation of new activities and projects, in order to promote the use and development of renewable energy technologies, as well as exploiting synergy effects and focus on renewable energy systems.
- Promotion of international cooperation by entering agreements with institutions world-wide, focusing on renewable energy.
- Coordination of research, education, and dissemination activities.

More information: [www.sffe.no](http://www.sffe.no)

#### Research Areas

The SFFE-network at NTNU, SINTEF and IFE involves around 200 scientific staff and 55 PhD students. Research is being conducted with respect to a range of technologies and issues related to renewable energy:

- Solar energy – production of power (solar cell silicon) and heat
- Small-scale hydropower
- Wind energy (onshore and offshore)
- Bio energy
- Energy from the ocean (wave, tidal, salt gradients)
- Ambient heat (utilized by heat pumps to cover low value heating demand)
- Geothermal energy
- Hydrogen technology for energy storage and conversion
- Energy system integration
- Social, economical and political issues.



Wind energy technology of tomorrow.

### Some highlights from 2005-2006

- A visible activity established; external profiling combined with good foundation in the internal specialist environments.
- Awarded a total of five PhD fellowships from the Research Council, where focus primarily has been on offshore renewable energy.
- Exhibition at Technoport 2005, where the educational programs as well as the research activities were profiled.
- Initiation of new projects; such as the granted application within deep sea offshore wind turbine technology.
- Improved cooperation with industrial and public partners.
- Facilitation towards the 7<sup>th</sup> Framework programme in the EU.
- International cooperation, with for example AIST in Japan and the European Renewable Energy Centres Agency (EUREC). SFPE became a member of EUREC in 2006.
- A number of seminars and workshop about renewable energy has been held.
- Improved teaching within renewable energy. This includes the initiation of a new Masters Programme in renewable energy systems in East Africa, funded by NORAD.



*The SFPE informs public participants and decision-makers about future possibilities within renewable energy (Photo: Bjørg Hernes)*

## The Gas Technology Center NTNU-SINTEF

The Gas Technology Center was established in 2003 and is the largest centre for gas technology research and education in Norway. The centre provides new knowledge and technology which will contribute to efficient, value creating and environmentally friendly utilization of natural gas.

The objective of the Gas Technology Center NTNU-SINTEF is to increase the quality, efficiency and scope of gas technology education, research, development and innovation in Norway. This is to be achieved by coordinating and establishing new activities in the area at NTNU and SINTEF.

### Research Areas

Approximately 300 people (researchers, professors, Post Docs and PhD students) are involved in natural gas-related R&D at NTNU and SINTEF. The Centre focuses on exploring the synergism of multidisciplinary research into the natural gas value chain. The Gas Technology Center handles technology in the entire value chain from source to end-user. Research areas include:

- CO<sub>2</sub> management and value chain
- LNG and gas to liquids (GTL) for the world market
- Offshore fields development including sub-sea technology
- Industrial gas processing and gas products
- Production, storage and use of hydrogen
- Gas engines
- Infrastructure and techno-economic optimization of gas value creation.

### Some highlights from 2005-2006

- Contributed to the BRU-applications for a Centre for Research-based Innovation application for e-field and Integrated Operations (granted)
- A number of conferences and seminars has been organised, such as "The Remote Monitoring Conference", "The Third Trondheim Conference on CO<sub>2</sub> Capture, Transport and Storage", "U.S. – Norway Late Summer School" and internal CO<sub>2</sub>-seminar for NTNU and SINTEF.
- Initiation of new projects; such as within arctic gas technology.
- Involved in initiating the national research program GASSMAKS, a new program addressing downstream industrial value creation from natural gas.

- Awarded a total of five PhD fellowships from the Research Council, where focus primarily has been on membranes and combustion.
- The Gas Technology Center was selected by the International Energy Agency Greenhouse Gas R&D Programme to plan and host the world's largest conference on Greenhouse Gas Control Technologies (GHGT-8). The conference was successfully organised at the NTNU-SINTEF campus June 19-22 2006 with 1000 participants from 47 countries – 430 papers presented
- Preparation for EU's 7th Framework Programme, including involvement in the Technology platform "Zero Emission Fossil Fuel Power Plants".
- Finalized successfully a Research council-funded Strategic University Program: *PSE – from Natural Gas to Energy and Materials Products* (2002 –2006). The project was a catalyst for establishing the Gas Technology Center.



## Centre for Better Resource Utilization NTNU-SINTEF (BRU)

In September 2004 NTNU's Board of Directors included the upstream petroleum area as a part of the strategic area Energy and Petroleum – Resources and Environment. In 2004-2005, a major effort has been invested in developing a new strategic plan for petroleum exploration and production at NTNU. An important element of the development has been visits to and discussions with around 50 oil and gas companies, service companies, governmental agencies, organizations, and the Norwegian Research Council. Based on these visits, and discussions at a seminar at NTNU August 2005, the final BRU Report was published on September 15, 2005. The report may be downloaded from <http://www.petroleum.ntnu.no/~kleppe/BRUreport.pdf>. The strategic plan identified four key areas for research in the years to come:

- Finding and Producing
- Drilling and Subsea Technology
- Integrated Operations in the Petroleum Industry
- Arctic Technology.

Subsequently, task forces in each area have been developing plans for activities to be started in order to enhance research activities. Current status is:

### **Finding and Producing**

The ROSE program in geophysics and geomechanics with focus on PhD research



*Advanced virtual reality laboratory opens for new insights.*

is supported by The Research Council of Norway as a Strategic University program (SUP). It has attracted around 10 oil companies as consortium members. Proceedings are published from annual workshops. A new collaboration agreement with Statoil added a new Statoil Research Professorship in seismology to the NTNU staff in September 2006. A number of new PhD scholarships were initiated through grants from Petromax (3), TOTAL (1), Hydro (2), and Statoil (6). In addition, as part of the new ISP, one PhD and one Post doc position were added.

### **Drilling and Subsea technology**

Major research efforts are invested in cheaper drilling, with experimental collaboration with Russia. Also, the ISP

program includes a new PhD position in subsea technology. NTNU is research partner in a new Research Council project for real-time drilling analysis, with the newly established company Volve.

### **Integrated Operations**

The Research Council of Norway granted NTNU status as Centre of Research Based Innovation (SFI) in the area of Integrated Operations. NTNU is host organization, with SINTEF and IFE as research partners. Norsk Hydro, Statoil, TOTAL, Petoro, Shell, ConocoPhillips, Gaz de France, IBM, Kongsberg Maritime, FMC and Aker Kværner have become industrial partner to the centre. The total research budget of the centre is 40 MNOK per year for a period of 5-8 years. NTNU is also a partner in a new Research Council project on Control Room Development, with DnV as host institution.

### **Arctic Technology**

EXTRA, a program focusing on exploration in arctic areas, is a joint project between Norwegian Geological Survey (NGU), SINTEF and NTNU. The multi-phase flow groups at NTNU, SINTEF and IFE have been granted status as Centre of Research Based Innovation (SFI) in the area of Flow Assurance, an area which will be central in developing transport over long distances in the Barents Sea. IFE is host institution, with SINTEF and NTNU as research partners. A number of oil companies are industrial partners, and the centre has a budget of around 40 MNOK per year for a period of 5-8 years.



*The new Integrated Operation facility.*

### Research is conducted in most areas of exploration and production

- Drilling technology.
- Subsea technology.
- Geomechanics.
- Reservoir technology.
- Drilling fluids.
- Well technology.
- Seismic processing.
- Multi-phase flow in pipelines.
- Geology.
- Hydrocarbon analysis.
- Seismic interpretation.
- Production.
- Gas technology.
- Hydrates.
- Petrophysics.
- Reservoir simulation.

Some additional highlights from 2006

- Three new doctorates in exploration and production graduated in 2006
- New Research Council projects in Reservoir Simulation and 4D Seismics, in Improved Oil recovery, and real-time drilling analysis.
- 80 publications and reports.
- Long term collaboration agreements with Norsk Hydro, Statoil and BP renewed
- A new building was added to the Department of Petroleum Engineering and Applied Geophysics, including library, lecture rooms and control room facilities.
- An MOU with Azerbaijan State Oil Academy was entered in 2006.
- New collaborative projects aimed at developing petroleum education with Angola, Bangladesh and Mosambique, supported by NORAD (NOMA).
- The student application to the petroleum studies programme at NTNU increased dramatically in 2006, and the fraction of women students admitted exceeded for the first time 50%.

### Centre for Energy and Society

To manage the production and use of energy to cater for a broad spectrum of social needs and in a sustainable way, is a great challenge. This calls for new and innovative strategies related to policy, technology, economy, and everyday life. The Centre for Energy and Society has been set up to do research to support the formulation of such strategies. In particular, the challenge of global warming and the need to curb the emission of CO<sub>2</sub> and other greenhouse gases makes the need for new approaches to energy production and consumption even larger. This means that modern societies need to assess its management of energy but also the diverse options that exists for the future. Such assessments have to draw on insights from the social sciences and the humanities. What concerns influences investments in new production of energy? What are the strengths and weaknesses of existing options to produce renewable energy in terms of their social, economic and cultural aspects? How may society facilitate the design of buildings that use less energy? How will the climate issues influence ways of thinking about energy?

These are questions that the Centre for Energy and Society addresses through its ongoing research. Of course, such questions have to be answered in dialogue with architects and engineers. Consequently, the centre gives priority to such dialogues with many actors and has ongoing collaboration with most of the other centres. Compared to the other centres, the Centre for Energy and Society is fairly small, comprising 10 researchers (including four PhD students).

#### Research Areas

- Energy policy and the politics of new renewable energy
- Energy and everyday life
- Energy, energy use and the design of buildings
- The cultural dynamics of new renewable energy technologies
- Visions of the Hydrogen Society
- Energy markets and energy actors
- Climate change and climate knowledge: How it is understood and how it is acted upon.

#### Some highlights from 2005-2006

- Three new projects funded by the Research council of Norway

- 8 peer reviewed papers and 32 presentations at workshop and conferences
- One new PhD graduated in 2006
- A paper that shows how journalists and the news media present knowledge about climate change in a highly dramatised format was referred to in several leading newspapers, including Norway's largest paper Verdens Gang, who spent two whole pages.

### Strategic Initiative "Green Innovation"

The 'Green Innovation' research group was created by the strategic research area in 2005. Its research combines insight into energy and environment issues in a broad sense with knowledge about innovation and implementation of technology to achieve large-scale environmental change. A main goal is to study innovation processes and in particular barriers and driving forces in order to understand how change happens. Research focus includes strategy and innovation theory, economic growth and technology change, as well as system dynamics and value sequence activities optimization.

#### Results from 2005-2006

- Award of an externally funded PhD scholarship and a PhD scholarship from NTNU
- Strategic cooperation with the Norwegian Institute of Strategic Studies (NORISS) initiated
- Started up development of a Centre for Applied Innovation Theory at the NTNU
- Publications, lectures and interviews.

## ENGAS Research Infrastructure

In the last 30 years NTNU and its technology transfer partner SINTEF have jointly developed an 8,000 square metre, 38 million Euro research facility, the **ENGAS** Research Infrastructure. Here, work is done to find ways to clean up CO<sub>2</sub>, NO<sub>x</sub>, SO<sub>x</sub> and other greenhouse gases, as well as investigating the removal of these gases from the oil and gas production processes and their use in industry, buildings and transport.

The Research Infrastructure offers foreign researchers access to an integrated complex of 14 unique laboratories for focused and trans-boundary research within the field of environmental gas management. These laboratories are designed to solve problems related to reducing emissions from the entire technology chain from energy source to end-user. The laboratories have been successfully used in developing new innovative technology and solutions, together with global industrial partners (<http://www.ntnu.no/engas/>).

### Main events in 2005-2006

- The energy area is involved in three newly awarded "Centres of Research-based Innovation" (CRI), funded by the Research Council of Norway and industry: "Integrated operation" (NTNU-SINTEF-IFE), "Multiphase Flow Assurance" (IFE-SINTEF-NTNU) and "Innovative Natural Gas Processes and Products" (UiO-NTNU). We were also "finalists" on two Centre of Excellence Applications; "Enabling Research and Technology for CO<sub>2</sub> Capture" and "Energy and Environmental Catalysis"
- The activity of the area was presented to their Majesties the Emperor and Empress of Japan during their visit to NTNU May 13 2005
- The area participated in organising three energy related Innovation Norway seminars during ExPo 2005 in Aichi Japan
- NTNU organized the renowned energy conference ECOS June 20-25, 2005
- NTNU-SINTEF organized the "7th IIR Gustav Lorentzen Conference on Natural Working Fluids" May 28-31, 2006, with 300 participants from 25 countries – 115 papers presented
- Gas Technology Center NTNU-SINTEF organized IEAs "8th International Conference on Greenhouse Gas Control Technologies" (GHGT-8) June 19-22, with

## New Research Council of Norway projects in 2005–2006

- Engineering Science for a Sustainable Future - Institutionally Based Strategic Program (ISP) from Research Council of Norway – 16 PhDs and Postdoc Fellowships within "Energy from the North" and "Renewable Energy"
- Paradoxes of design. Aesthetication as a barrier to sustainable consumption
- Preparing for a rainy day? Configuring climate science for future society
- Building markets, shaping policy? The role of economics in energy policy and energy use
- Climate knowledge on the road.
- aCOM, Cost Effective Utilization of Bioenergy - Advanced Biomass and Waste Combustion (RENERGI, SINTEF Energy Research, 2006-2008, [www.energy.sintef.no/prosjekt/acom](http://www.energy.sintef.no/prosjekt/acom))
- Deep sea offshore wind turbine technology (RENERGI (KMB), SINTEF Energy Research, 2007-)
- EKSBO - Factor 4 Building Renovation (NFR/Norwegian State Housing Bank, various industry, SINTEF Building and Infrastructure, 2006-2009)
- Offshore renewable energy, Pilot project PhD-pool (RENERGI, 2005-)
- Technology development for integrated SOFC, biomass gasification and high temperature gas cleaning - Up-scaling and long term testing (RENERGI, NTNU, Johan E. Hustad, 2005-)
- BIG CO<sub>2</sub>: CO<sub>2</sub> Management Technologies for Future Power Generation.
- BIG CLC: Demonstration of Chemical Looping Technology in Natural Gas Power Generation with CO<sub>2</sub> Capture.
- Research program MIT-NTNU on natural gas technology (Transportation systems, Hydrogen production and CO<sub>2</sub> capture)
- Efficient Hydrogen Liquefaction Processes: Improving the energy efficiency for liquefaction.
- Optimal Design and Operation of Gas Processing Plants: Increase the value of natural gas by better operation and design of processing plants for natural gas
- Enabling production of Remote Gas: Address the critical technology barriers related to floating production of natural gas from smaller fields through a coordinated effort by industry and research institutions.
- Centre for Research-based Innovation (CRI) for e-field and Integrated Operations.

1000 participants (!) from 47 countries  
– 430 papers presented

- August 2006 – Start up of MIT-NTNU research program on development of gas technology. The 18 million NOK program consist of three basic research projects, financed by Statoil, Hydro and Research Council of Norway
- Contributing to "Polen 2006" by organising large Seminar on "Energy and Environment" October 18, 2006, with 120 participants from universities, research institutes and industry, within workshops on "Clean coal technology", "Gas technology", "Renewable energy" and "Energy in Buildings"
- On September 6 to 8, 2006 NTNU organised the first KIFEE Symposium on Environment and Energy outside Japan – 150 participants and 51 presentations (KIFEE = Kyoto International Forum for Environment and Energy)



## EU Framework projects at NTNU and SINTEF

- PRIME Policies for Research and Innovation in the Move towards the European Research Area (Network of excellence)
- PEP - Promotion of European Passive Houses, ([www.europeanpassivehouses.org](http://www.europeanpassivehouses.org))
- ECO-CITY: Joint Eco-City Developments in Scandinavia and Spain, <http://www.ecocity-project.eu/>
- BRITA in PUBs: Bringing Retrofit Innovation to Application in Public Buildings, <http://www.brita-in-pubs.eu/>
- TREES: Training for Renovated Energy Efficient Social Housing, <http://www.cenrg.ensmp.fr/trees/>
- 3-NITY: 3-fold Initiative for Energy Planning and Sustainable Development at Local Level.
- EMINENT: Early Market Introduction of New Energy Technologies.
- FOXY: Development of solar-grade silicon feedstock for X wafers and cells.
- FCTEDI: Fuel Cell test and dissemination network, SSA-Strategic support action.
- GreenNet-EU27: Guiding a Least Cost Grid Integration of RES-Electricity in an extended Europe.
- NextGenBioWaste: Innovative demonstrations for the next generation of biomass and waste combustion plants.
- SEEWEC: Sustainable Economically Efficient Wave Energy Converter.
- SISI: Silicon for solar cells at low costs on an intermediate scale.
- ThermalNet: European Network for biomass pyrolysis, gasification and combustion.
- WAVESSG: Full-scale demonstration of robust and high-efficiency wave energy converter.
- WILMAR: Wind Power Integration in Liberalized Electricity Markets.
- DYNAMIS: Towards Hydrogen and Electricity Production with CO<sub>2</sub> Capture and Storage (Coordinator)
- ENGAS: Environmental Gas Management Research Infrastructure (Coordinator)
- ENCAP: Enhanced Capture of CO<sub>2</sub> (Project manager)
- CO2Remove: Geological storage of CO<sub>2</sub>
- COACH: Co-operation Action within CCS EU-China
- CASTOR: CO<sub>2</sub> from Capture to Storage
- ULCOS: Ultra Low CO<sub>2</sub> Steelmaking
- INCACO2: International Co-operation Actions on CO<sub>2</sub> Capture and Storage

- CO2GeoNet: Network of Excellence in Geological Storage of CO<sub>2</sub>
- NATURALHY: Preparing for the hydrogen economy by using the existing natural gas system as a catalyst
- ZEP: The Technology Platform for Zero Emission Fossil Fuel Power Plants (two members)

## Other international projects at NTNU and SINTEF

### IEA – International Energy Agency

SmartBuild is participating in the following projects and programmes within the IEA:

- IEA ECBCS Annex 44: Integrating Environmentally Responsive Elements in Buildings <http://www.ecbcs.org/annexes/annex44.htm>
- IEA ECBCS Annex 47: Cost-effective Commissioning, <http://www.ecbcs.org/annexes/annex47.htm>
- IEA PVPS Task 10: Urban Scale PV, <http://www.iea-pvps-task10.org/>
- IEA Heat Pump Programme Annex 29: Ground-Source Heat Pumps Overcoming Technical and Market Barriers, <http://www.energy.sintef.no/prosjekt/Annex29/>



Partnership NTNU and MIT.

## International Cooperation

The Board has put much emphasis on international cooperation, giving priority to regions and countries where Norwegian scientists develop strategic industrial cooperation: the European Union (EU), Asia (Japan and China) and North America. The activity in 2005 and 2006 has been significant in all these regions.

### EU

By systematic strategic team-work NTNU and SINTEF have been able to establish ourselves successfully on the European research scene during the development of the 6th Framework programme (FP 6). Per 2006 we are involved in a substantial number of projects (see list) within Energy and Society, Energy in Buildings, Renewable energy, Hydrogen and Fuel Cells, and Zero Emission Fossil Fuel Power Plants. The projects have a total NTNU-SINTEF budget of 14 million Euros.

In 2006, full attention has been given to preparations for the 7th Framework programme. This work is now fully taken care of by the centres, since they have the important networks which were developed in the FP6.

### Japan

Supported by the Research Council of Norway (RCN) and Innovation Norway (IN) in Tokyo, the cooperation through the strategic network Kyoto International Forum for Environment and Energy has been further developed in 2005 and 2006. The biggest event in 2005 was the visit of their Majesties the Emperor and Empress of Japan to NTNU, where we were given the honour of presenting the KIFEE-cooperation. Also, NTNU-SINTEF participated in three energy related seminars organised by Innovation Norway in Tokyo in relation to the ExPo 2005. A new KIFEE Workshop was organised in Kyoto in October, with 130 participants, including 25 Norwegian. 51 presentations were given, and workshops organised to make plans for the cooperation within the four selected areas process engineering, advanced biological materials, advanced inorganic materials, and electrolysis systems.

Four BILAT-projects was awarded by the RCN to develop specific applications for joint projects.

In September 2006 NTNU was given the honour of organising the first KIFEE Symposium outside Japan. The successful symposium gathered 150 participants (40 from Japan) – and 53 presentations were given. The report may be found on [www.ntnu.no/kifee2006](http://www.ntnu.no/kifee2006).



*International co-operation: students involved in projects in Japan.*

In addition to KIFEE, NTNU and SINTEF have signed MoUs to develop research cooperation with the prestigious Japanese research institute National Institute of Advanced Industrial Science and Technology (AIST). A successful seminar was organised in Trondheim in October 2006 to plan how to develop the cooperation. The Centre for Renewable Energy has been awarded a BILAT-project to develop the cooperation with AIST on Renewable Energy, and several activities are planned in 2007

#### China

The systematic strategic work initiated in 2004 has been followed up throughout 2005 and 2006. Based on a study tour made in 2004, we organised a visit to the selected universities with a delegation headed by Rector in October 2005. Here, MoUs were signed and strategies for development of cooperation decided upon, i.e. areas that have been selected for long term cooperation. Xi'an University of Architecture and Technology

- Sustainable Rural Development Tsinghua University
  - Energy Conservation in Buildings; Hydrogen/Fuel Cells; Renewable Energy (wind, solar, bio); CO<sub>2</sub> management;
- Shanghai Jiao Tong University
- Gas Technology (LNG, Gas Engines, CO<sub>2</sub> as working fluid): Renewable Energy

Chongqing University

- \* Gas Technology

### What are the added values of the Strategic Area arrangement?

- One of the largest assets of NTNU is that the university covers a wide range of disciplines; engineering science, architecture, natural science, social sciences and the humanities. The Strategic Area is a tool to utilize this asset to do better research and to be more useful to society
- The Strategic Area brings excellent research groups from different disciplines together in goal-oriented team work to solve complicated problems that are of large importance to society. These complicated problems can only be solved by multidisciplinary team work, and we have the resources needed "in-house".
- By planning and carrying out things together successfully, we create better communication between disciplines. Walls between disciplines are eroding, and new multidisciplinary arenas emerge. Since multidisciplinary research is necessary to serve future needs of the industry and society as well as to do high quality research, this attracts new partners and facilitates commercialization of results.
- By working on larger problem areas as one team with a common strategy, we may also improve our visibility and impact, both nationally and internationally:
  - We have developed a strategic cooperation with the Research Council of Norway, achieving responsibility for development of larger projects and programs (it is easier to receive a readily made project package, than trying to put it together yourself by individual pieces).
  - We may also obtain better results in the European Research Area and strategic international cooperation.
- All this improves the chances for external funding of research projects, which has already been excellently demonstrated.

Above all it is a large asset that a Strategic Area acts "on behalf of NTNU", and that our Rector is supportive.

RCN has awarded four BILAT projects to prepare specific cooperation. In 2006 workshops and meetings have been organised within the areas of Building Energy, Hydrogen/Fuel Cells and Gas Technology. The preparation work will lead to start-up of projects in 2007.



*NTNU-students and Makerere-students attending a renewable energy course in Uganda (photo: SFFE)*

#### USA

In May 2004 USA and Norway signed a Memorandum of Understanding (MoU) on research cooperation within the energy sector, with special emphasis on CO<sub>2</sub>

management, hydrogen, and new energy technology. NTNU have worked to take an active part in this cooperation by developing strategic cooperation with MIT and University of Maryland.

Since 2002 NTNU has worked successfully to develop strategic cooperation with MIT and their Laboratory of Energy and the Environment. In 2004 we started the energy system project TRANSES (Alternatives for the Transition to Sustainable Energy Systems in Northern Europe), which involves Hydro, Statoil, Shell, Statsbygg, Enova, Statkraft and Statnett as sponsors. MIT, Chalmers, NTNU and SINTEF are research partners. In 2005 and 2006 we have developed the MIT-NTNU collaboration further, based on a strategy of 'paired professors' developed by our strategi advisors, Rolf Marstrand and Per-Erling Frivik. In the 'paired professor' model, two professors and two PhD-students from MIT and NTNU work together on a common project, and this seems to be a very promising approach. A workshop was organised on MIT in September 2005, with 25 participants from MIT, NTNU (including Rector) and the industrial sponsors Hydro

and Statoil. At this workshop 6 project-pairs were identified.

Also the cooperation with University of Maryland (UMCP) has made progress in 2006 through a BILAT-grant from RCN. A Seminar on Energy and Environment was organised at NTNU in November 2006 with 27 participants from UMCP, Joint Global Change Research Institute (JGCRI), University of Oslo, IFE, SINTEF and NTNU. Plans for development of cooperation were brought forward on hydrogen/fuel cells, combined cooling heating & power, reliability and safety, and the TRANSES project. These plans will be carried out in 2007

The BRU centre has a well-established cooperation with major partners in US, Holland and Brazil as well as with developing oil producing countries, such as Iran and India. In 2006 new education cooperation projects have been started up in Venezuela, Angola, Bangladesh and Mosambique, supported by NORAD.

## Board 2005

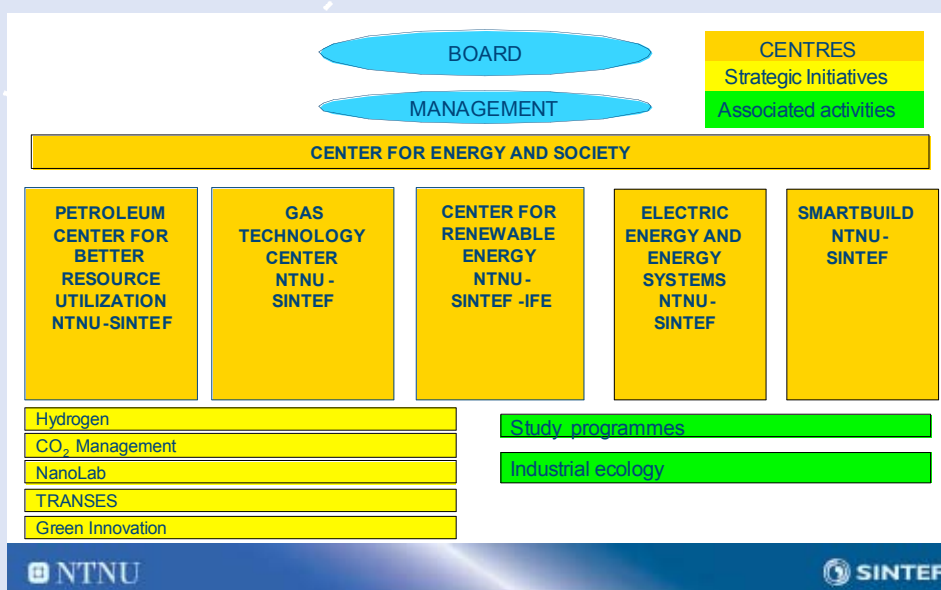
- Senior Vice President Bjørn Sund: Norsk Hydro (Chairman)
- CEO Eli Arnstad: Enova
- Director of Strategy Dag Vareide: Statoil
- Research director Stein Rognlien: Statsbygg
- Technical director Erik Sauar: REC ASA
- Executive Officer Sverre Aam : SINTEF Energy Research AS
- Dean David Nicholson: Faculty of Natural Science and Technology, NTNU
- Professor Hans H. Faanes: Faculty of Information Technology, Mathematics and Electrical Engineering, NTNU

## Management 2006

- Centre for Smart, Energy-Efficient Buildings: Professor Øyvind Aschehoug
- Centre for Renewable Energy NTNU-SINTEF: Professor Johan E. Hustad
- Gas Technology Center, NTNU-SINTEF: Professor Bjarne Foss, and Nils Røkke
- Centre for Better Resource Utilization (BRU): Professor Jon Kleppe
- Centre for Electrical Energy and Energy Systems: Professor Erling Ildstad
- Centre for Energy and Society: Professor Knut H. Sørensen
- Strategic Initiative "Hydrogen technology": Professor Hilde Venvik
- Strategic Initiative "CO<sub>2</sub> Management": Professor Olav Bolland
- Strategic Initiative "NanoLab": Professor Thomas Tybell
- Strategic Initiative "TRANSES": Dr. Bjørn Bakken
- Strategic Initiative "Green Innovation": Dr. Harald Gether
- Study programme Energy & Environment: Professor Ivar Wangensteen

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# Annual Report for Energy and Petroleum 2006



## **NTNU**

The Norwegian University of Science and Technology (NTNU) in Trondheim represents academic eminence in technology and the natural sciences as well as in other academic disciplines ranging from the social sciences, the arts, medicine, architecture and the fine arts. Cross-disciplinary cooperation results in ideas no one else has thought of, and creative solutions that change our daily lives.

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