Annual Report 2010

STRATEGIC AREA

Energy and Petroleum – Resources and Environment

NTNU's Rector Torbjørn Digernes and TSA Energy's Director Arne Bredesen signing the JRC-agreement with their colleagues at Shanghai Jiao Tong University in May 2010

NTNU – Trondheim
Norwegian University of
Science and Technology

What are NTNU's Strategic Areas?

One of the main goals of NTNU is 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 where multidisciplinary teamwork produces high-quality research with substantial long-term social impact. These are:

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

Visit us at **http://www.ntnu.edu/research/strategic_research_efforts**

Editor: Trond Kvilhaug
Layout and print: Tapir Uttrykk, NO-7005 Trondheim

About Energy and Petroleum–Resources and Environment

Energy is not just about money and economic growth. Energy is essential to the lives of people on this planet.

This is why NTNU placed energy on its main strategic agenda as early as 2000, and started to develop an organization based on goal-oriented multidisciplinary teamwork to handle the complex problems and challenges facing society surrounding this topic.

Energy is essential to society because we need it to provide for fundamental human needs, such as food, clothing, housing/shelter, transportation, health and recreation – in short, everything that is needed to live a good life on this planet.

By the end of this century, the countries of the world must collectively make substantial cuts in the emissions of greenhouse gases. During the same period several billion new world citizens will join us around the "global dinner table". Providing sufficient clean energy to ensure a peaceful and sustainable society for everyone in the future is one of the largest challenges facing global society today.

There will be an enormous demand for new knowledge, new technology, new solutions and new innovations to meet this global challenge. NTNU and our research partner SINTEF want to play an active and productive role in supplying the scientific and technological information and innovations essential to the global transformation process that will be essential to achieving a sustainable future.

Our overall goal is to develop new knowledge and technology in the clean energy field and educate people who can use that knowledge to create new clean energy solutions. A successful transition to clean and sustainable energy systems will depend on global innovations. The solutions that will be implemented will reflect local resources and conditions. They will, however, emerge from the application of a mixture of key technologies, with which NTNU and SINTEF are actively working.

By virtue of its hydropower and petroleum resources, and its favourable conditions for renewable energy, Norway may be considered an "energy country". For this reason, government and industry have invested in energy research and education in Trondheim for more than 100 years. By applying our teamwork strategy to identify challenges and opportunities and recruit multidisciplinary teams to handle them, NTNU and SINTEF have been successfully increasing our energy-related research and education efforts since the strategic area was established in 2000. Today there are more than 1200 people at NTNU and SINTEF working to create new knowledge, new technology and new solutions to realize our common vision:

Sufficient and clean energy for a sustainable and peaceful society

The "Energy Team" includes around 200 professors and almost 500 PhD candidates and postdoctoral students working with basic energy-related research. In addition, each year we graduate approximately 300 to 400 MSc candidates for the energy sector. Our combination of research and education constitutes a major advantage and added values for these highly qualified candidates bring with them the newest knowledge and skills, which they use for the rest of their working lives to solve problems and create new "clean" solutions for the benefit of the society.

The TSA Energy Team as per today (2010) is involved in a number of multidisciplinary activities, principally six goal-oriented multidisciplinary research centres:

- Centre for Energy and Society (NTNU)
- Centre for Sustainable Buildings (NTNU-SINTEF
- Centre for Renewable Energy (NTNU-SINTEF-IFE-UiO)
- Gas Technology Centre (NTNU-SINTEF)
- Petroleum Centre for Better Resource Utilization (NTNU-SINTEF)
- Centre for Electric Energy and Energy Systems (NTNU-SINTEF)

In addition, we have developed strategic initiatives that involve cross-disciplinary work between the centres:

- CO_2 Capture and Storage (CCS)
- Hydrogen Technology
- Green Innovation

Research teams from TSA Energy are involved in the following national Centres of Excellence:

Four Centres for Research Based Innovation (CRI)

- Integrated Operations
- Multiphase Flow Assurance
- Innovative Natural Gas Processes and Products
- Drilling and Well Technology for Improved Recovery

Seven Centres for Environment-Friendly Energy Research (FME) (start up 2009–2010)

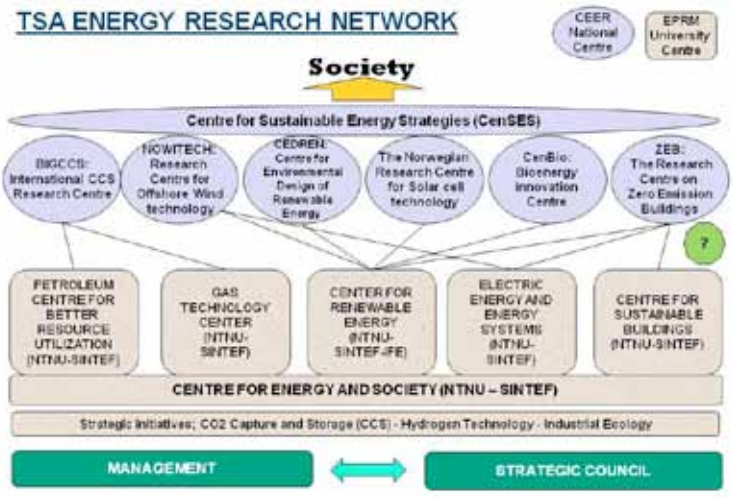
- BIGCCS – International CCS Research Centre
- Centre for Environmental Design of Renewable Energy (CEDREN)
- Bioenergy Innovation Centre (CenBio)
- Norwegian Research Centre for Offshore Wind Technology (NOWITECH)
- The Norwegian Research Centre for Solar Cell Technology
- The Research Centre for Zero Emission Buildings (ZEB)
- Centre for Sustainable Energy Strategies (CenSES) (approved in 2011)

These FMEs constitute a total research investment of more than 2.5 billion NOK over 8 years and operate as a close cooperative effort between universities, research institutes and industry. The industrial partners provide 25% of the funding, while the remainder is provided by the Research Council of Norway (50%) and NTNU/SINTEF. Close to 200 PhDs and postdocs will be educated. This puts NTNU and SINTEF in a strong position to participate in and make positive contributions to the challenging work that lies ahead.

Our main strategic cooperation partners are the Norwegian government, the Research Council of Norway and the Norwegian energy industry. The goal of this national team is to lay the foundation for a new environment-friendly "energy revolution". This will be the third such energy revolution over the course of NTNU's 100-year-long history:

- The first was to develop hydropower as an energy source for Norway's industrial development. Norway had no coal and we had to find other ways to provide energy for industrial and societal development.
- The second was to develop new technological solutions, among them drilling technology, subsea platforms, multiphase flow and LNG technology, which completely changed the way we produce oil and gas from offshore fields.
- Now the aim is to invent new approaches to climate friendly energy, based on renewable energy, CCS and energy efficiency.

TSA Energy relies heavily on cooperation and coordination with the different NTNU faculties and departments. The team is organized to involve highly professional and unique research groups that handle strategically important areas in science and technology. There are close to 30 such research groups in our strategic area. The teams consist of NTNU professors, SINTEF researchers and PhD and MSc students who work in state-of-the-art laboratories. These research groups have been created by the faculties through the allocation of personnel resources and laboratory investments. The development of new research groups to handle future new technology areas thus relies on good communication between the faculties and TSA Energy. The Faculty-Centre-Matrix below shows how we have developed cooperative networks with almost all NTNU's faculties.



Schematic sketch of TSA Energy's network

FACULTY – CENTRE – MATRIX

	Contribution to Centres					
Faculty of:	**CSB**	**EEES**	**CRE**	**GTC**	**BRU**	**CES**
Architecture and Fine Art	X		X			
Engineering Science and Technology	X	X	X	X	X	X
Natural Sciences and Technology			X	X	X	
Information Technology, Mathematics and Electrical Engineering		X	X	X	X	
Social Sciences and Technology Management		X	X	X	X	
Humanities	X		X			X

Visit us at http://www.ntnu.edu/energy

Main events in 2010

- Signing of an agreement on a Joint Research Centre (JRC) for "Sustainable Energy" between Shanghai Jiao Tong University (SJTU) and NTNU by President Jie Zhang and Rector Torbjørn Digernes in Shanghai (May 26).
- Visit by the Minister of Research and Higher Education, Tora Aasland, announcing funding for development of the European Carbon Capture and StoragE Laboratory Infrastructure (ECCSEL) (November 16).
- The Petroleum Centre for Better Resource Utilization (BRU) was partner in a newly appointed Centre for Research Based Innovation (CRI) "Drilling and Well Technology for Improved Recovery".
- The Centre for Renewable Energy launched the first "Renewable Research Conference (RERC)" in Trondheim. RERC addressed almost all fields of renewable energy in 8 parallel sessions, with 400 participants from 15 countries (June 7-8).
- The Gas Technology Centre initiated 4 new projects under the EU's Fuel Cells and Hydrogen Joint Undertaking (FCH JU). The projects will begin in 2011.
- BRU's Centre for Integrated Operations hosted the 7th international conference in the area of Smart Fields/ Integrated Operations. Rector Torbjørn Digernes opened the conference, which attracted 280 participants (September 13-14).
- BRU hosted the 6th international conference on Rock Physics and Seismic (ROSE10) with 75 participants. The conference was followed by a two-day short course in Seismic Imaging (April 19-20).
- The Gas Technology Centre hosted the one week "IEAGHG International Summer School" in Spitsbergen, Svalbard, in cooperation with BIGCCS, SUCCESS and UNIS (University Centre of Svalbard). Fifty-six students from 32 countries participated with 30 expert lecturers and mentors (August 22-28).
- NTNU launched a new international Master's programme in "Sustainable Architecture".
- Master's students from the "Sustainable Architecture" programme qualified for the finals in the "Solar Decathlon Europe 2012" competition with their project, called "Zero Emission Hut" (ZE+H). Twenty finalists have been selected to exhibit their solution in Madrid in 2012.
- The Centre for Sustainable Buildings organized a major conference and seminar on "Architecture and Energy" and "2PC Built Form" in March.
- Industrial Ecology Programme received the 2009 Best Environmental Policy Paper award from Environmental Science and Technology and received high-profile media attention during the launching of the report "Priority Products and Materials" for the United Nation's Resource Panel.
- The Preparatory Phase Project for the Pan-European Laboratory ECCSEL initiative was approved with a budget of 15 million NOK for the first 2 years..
- NTNU joined the European Partnership for Sustainable Energy Education, Innovation and Technology (SEEIT), in cooperation with DTU, TU Delft, TU Münich, ALU Freiburg, Aalto University, Politecnico Torino, SINTEF, ENEA, and Fraunhofer ISE. SEEIT will work on bio energy, wind energy, solar energy, energy efficiency and energy systems.
- Eli Blakstad, State Secretary for the Ministry of Petroleum and Energy, opened the first part of the green innovation project "Active Dynamic Thermal Storage for Industrial Processes". The KMB is funded by the Research Council of Norway, ENOVA and the County of Nord-Trøndelag.
- Researchers from the Gas Technology Centre participated in the Norwegian Hydrogen Technology delegation study tour to Japan in October.
- The Think Tank project, initiated by the Minister of Petroleum and Energy was expanded under the official name "Grønn Fase" (Green Phase) – (see http://gronnfase.blogspot.com/). The project involves students working in different FMEs, and one action in 2010 was to establish an energy prize for young researchers. The 2010 prize winner, Hanne Risan Johnsen from the University of Tromsø, received 50 000 NOK for her work on biofuels. The prize was presented during the RERC conference.

Energy & Petroleum – Resources & Environment in 2010

NTNU's centennial celebration in 2010 was also a major event for TSA Energy. We contributed to the celebration by making NTNU more visible both nationally and internationally, and have been able to strengthen our position and activity because of the celebration. The NTNU Jubilee expedition to China in May-June, headed by NTNU's rector, was a major event for development of our strategic research cooperation with different Chinese universities (see Internationalization).

The initiation of activity in the different Centres for Environment-Friendly Energy Research (FMEs) has been a major achievement both for the research groups involved and NTNU's administration. The FMEs have been heavily/successfully employed by the Research Council, NTNU and SINTEF as target areas for developing strategic international cooperation on "Environment friendly energy".

What follows are the most important points from the new strategic plan for 2011-2015, which was crafted using an inclusive process, including a "family gathering" in the autumn, where individuals from NTNU (Faculties and Departments), SINTEF and the FMEs provided active input to a final plan that was approved by the Strategic Council in November.

Strategies for 2011–2015

To contribute to our vision and overall energy strategy, TSA Energy will give priority to the following main areas/key technologies in the period from 2011–2015:

- Sustainable energy strategies – social sciences (CenSES)
- Efficient end use of energy (especially in buildings)
- Utilization of renewable energy sources (offshore wind, solar energy, bio energy, hydropower)
- Carbon Capture and Storage (CCS) to allow the use of fossil fuels in future
- Smart energy systems (SmartGrids) that integrate sources and end users in an efficient way
- Utilization of natural gas in an environmentally friendly way
- Better resource utilization and energy from the arctic region
- Hydrogen technology

Our priorities are based upon Norway's position near to the North Sea and the Arctic Basin, with large potential and reserves of renewable energy, oil and natural gas. These are robust areas that coincide well with the key technology areas published in an international prognosis (ref. IEA Energy Technology Perspectives 2010), and also the national Energy 21 strategy. Nuclear energy is another key technology internationally, but is not a part of our energy strategy.

Our research in most of these areas is already strong, but there are subjects that need to be improved. Fostering teamwork between the social sciences and technology is of special concern. Under the different main areas/key technologies, we will give priority to the following strategic initiatives during the period of the plan:

- Create arenas for cooperation between CenSES and the different technology areas, to improve our understanding of how new energy solutions may be realized and accepted and utilized by society.
- Strengthen our activity in "SmartGrids" (also called "Networks of the Future") in cooperation with TSA ICT (Information and Communication Technology).
- Utilize the results from the FMEs in our education and innovation.

Towards the end of the plan period we will start planning new large initiatives to follow up on the FMEs.

The strategic plan also contains strategies for the following areas:

- Strategic communication efforts with the Research Council of Norway, Energy21 and other funding agencies
- Science dissemination and communication with public, with the development of an "Energy Arena"
- Internationalization (EU, Japan, China, USA, India, South Africa, Russia and Brazil)
- Education – communication to young people – International master's programmes
- Laboratory research infrastructures – Road maps for "Energy revolution" laboratories

It should be mentioned that the Board of Energy21 is now working on a new national strategy to identify the most important research areas needed to realize the vision elucidated in the document: "Norway: "Europe's energy and environment nation – from national balance to green delivery". The first strategy resulted in the establishment of the FMEs. Now Energy21 is working on a new more goal-oriented strategy with respect to research. In 2010, more than 140 people from the industry, research institutions and the university have been involved in creating more specific plans under the six priority areas:

Offshore Wind (photo: Siemens)

1. Renewable power
2. Future energy systems
3. Energy efficiency in industry
4. Renewable thermal energy
5. Carbon capture, transport and storage
6. Framework conditions and social analysis

Researchers from NTNU and SINTEF have participated in this process, which will end in a new strategy in June 2011. NTNU and SINTEF are also represented on the Energy21 Board.

Energy Campus North

The Arctic will be an important energy region in the future, but only if we explore and develop its valuable energy sources (oil, gas and renewable sources) in a sustainable way. The Norwegian government has put the Arctic region on its agenda through the High North Initiative, and NTNU wants to contribute with its skills and competence to achieve the initiative's ambitious goals.

One important area is education. Here we have teamed up with the University of Tromsø and the University Colleges in Finnmark and Narvik to create Energy Campus North (ECN) in Hammerfest. A long-term goal is to develop an integrated education programme in energy technology, consisting of bachelor's and master's degrees, and continuing education and teacher training programmes. The long-term vision is to increase the energy-related expertise in the region so that it is prepared for a future where energy and fisheries dominate the Norwegian economy.

Energy Campus North is an initiative that has been fronted by NTNU's Rectorate, because it is an important strategic effort that will demonstrate how NTNU can make its national expertise available to innovative programmes in other parts of the country. The initiative is being handled by the strategic area on behalf of NTNU's Rectorate.

Centre for Sustainable Buildings (CSB)

This centre's main objective is to develop new knowledge, integrated solutions and technologies to address the energy demands in buildings that reduce the negative consequences for the environment. CSB has developed strategic goals for the following topics:

- Research and development
- Education
- International and outreach activities

A major turning point for this centre was the establishment of Zero Emission Buildings (ZEB), a national Centre for Environmental Energy Research for this thematic strategic area in 2009. This centre will operate from 2009–2017, and will address many of the activities planned for R&D in CSB. There are, however, also NTNU and SINTEF units collaborating in CSB that are not participants in ZEB.

Main results 2010

Multidisciplinary centre research collaboration

CSB organized and sponsored 2 major conference and seminar activities in 2010. The seminar "Architecture and Energy" took place in a packed Dokkhuset auditorium in March, with 3 presentations by international experts. Afterwards, ZEB and related topics were presented, both by ZEB candidates and local experts. The seminar was followed the next day by the workshop "2PC Built Form" on the NTNU campus, with the title inspired by the Norwegian carbon objective to reduce the country's CO2 emissions to 2 tons per capita.

In May, the NTNU Department of Interdisciplinary Studies of Culture conducted an off-campus seminar on interdisciplinary energy research, aimed primarily at our PhD candidates as a component in a future "researchers school". The seminar was held at Stokkøya, on the coast north of Trondheim.

The ZEB centre has added more PhD and postdoc candidates in 2010, totalling 12 at the end of 2010. Four of these are being financed through TSA Energy, while the rest are funded through ZEB financing.

Educational activities and support for research training

CSB has granted financial support to the establishment of a more formalized research school, organized under a planned Centre for Sustainable Infrastructure at the Faculty of Engineering Science and Technology. This initiative was granted financial support in 2010, but the centre is still being planned. The same situation holds for an initiative to establish a Centre for Energy Use and Interior Climate in the same faculty, but a different department.

The Faculty of Architecture and Fine Art started a new international Master's programme for Sustainable Architecture in 2010. The course has attracted a large number of applicants, both from abroad and from Norway. The students and faculty in the programme, along with ZEB researchers, participated in the international Solar Decathlon Europe 2012 competition, and were awarded one of 20 places in the final round of the competition. Their proposed building project, the solar zero-energy house "ZE+Hytte" (Zero Energy Cabin) will be built in Madrid for an exposition in 2012, and later moved to Trondheim (see image). CSB has provided start-up financing for this work. This building will most likely located in the planned low-carbon Brøset city development in Trondheim.

CSB has also decided to support the establishment of a Nordic chapter of IBPSA, the International Building Performance Simulation Association. Similar support was granted for an undergraduate seminar in 2011, directed by a German climate expert.

International and outreach activities

Many of the CSB activities reported above could also be classified under this heading. The total Thematic Strategic Area Energy was presented during a NTNU visit to China in conjunction with the Shanghai Expo in 2010, and Joint Research Agreements have been signed with Chinese universities in the building energy field. A NTNU MSc student at the Department of Interdisciplinary Studies of Culture has spent time in China and produced a report on "Sustainability and Cooperation" with a list of universities and other research institutions in China that would be suitable co-operators with CSB.

CSB and ZEB have both been active in the EU's 7th RDD Framework applications. The Private/Public Partnership demonstration project proposal called NZ: Elderly was unfortunately not successful. Through the SEEIT network, where NTNU has decided to play an active role, we are participating in a Marie Curie ITN and an Erasmus Joint Doctorate Programme application.

Existing international cooperative efforts continued in 2010. Our Polish colleagues at the Warsaw University of Technology are now close to finishing of their STEP project, Sustainable Thermo-Modernization of Public Buildings, with funding from the Norwegian EEA Grant mechanism. CSB participated in a R&D conference staged by the Norwegian Embassy in Warsaw in November and in the final STEP conference in December.

The solar zero energy house "ZE+Hytte"

Centre for Electric Energy and Energy Systems

The research centre plays an active role in developing technology for the production, transportation and utilisation of electric energy. The Gemini Centre unites the research activity at NTNU's Department of Electric Power Engineering and the Electric Power Technology and Energy Systems Departments at SINTEF Energy Research. The centre continued its research activities in the following main areas:

Methods for planning and operating energy supply systems
- Energy markets: Trading arrangements, financial issues and the environment
- Supply reliability in non-regulated power systems
- End-users: Quality and reliable power supply

Transport of electricity
- Materials and components for HVDC
- Condition monitoring, maintenance and refurbishment
- Over-voltage calculations and insulation coordination

Generation, transforming and use of electrical energy
- Renewable sources of energy and new efficient energy systems
- Maritime systems: Shipping, offshore, power supply to subsea oil and gas installations
- Installation systems and energy consumption in buildings
- Power electronic drives and control of electric motors

The Energy and the Environment Study Programme
The study programme is a cooperative effort between the Department of Electric Power Engineering and the Department of Energy and Process Engineering. The recruitment of students to the programme was high both in 2009 and 2010. A total of 155 are now enrolled. The number of female students is stable, at around 40%. The admission requirements show an increasing trend despite the increasing number of students. In 2010, significant progress has been made on the evaluation of the future Energy and the Environment study programme (FREMS), due to begin in 2012.

Research
The research centre actively participates in the NOWITECH (FME), an initiative where NTNU, SINTEF and IFE are partners in close coordination with Norwegian industry. The research activities at the centre are related to offshore wind power generation, conversion, transmission and integration both from a technical and economic aspect.

An initiative to develop power systems of the future (Smartgrid) was made in 2010 by the centre. A national Smartgrid centre is under construction with participation of four university/research institutions and wide industry involvement. This is an interdisciplinary activity where departments from 6 of NTNU 7 faculties are involved. Many new PhD projects have been started under this umbrella. The IME faculty has allocated 12 PhD/postdoc positions using strategic funding to support the initiative. New research projects with support from the Norwegian Research Council have been initiated and recruitment of PhD students is in progress.

The centre also participated in the EU project called MARINA, with a focus on offshore platforms that convert different energy forms (such as wind and wave) into electrical energy. The project started in 2010 and will be partially supported by the centre's contribution of 3.5 years full-time equivalent.

Our close cooperation with SINTEF Energy Research is carried out through the continuation of a GEMINI centre. Several new KMB projects were established in 2010, which helped bringing new PhD candidates to the centre.

International collaboration
The scientific personal at the centre actively participate in international research groups and technical committees and are in the leadership of several groups. IEEE PowerTech, an excellent technical conference, will be held in Trondheim in June 2011.

In 2010, the centre was involved with development of a new international MSc programme on Wind Energy together with DTU, Denmark, TU Delft, Netherlands, Univ. of Oldenburg, Germany. Funding for this initiative has been sought from the Erasmus Mundus programme. Similar initiatives for joint international MSc programmes under SmartGrid are under discussions with other well-respected universities.

Industrial collaboration
The centre works closely with the industry, particularly in energy conservation, where the direct interaction is quite strong. A part-time professorship and several PhD students are funded directly by the industry, and a significant number of MSc final projects are conducted as joint projects with industry partners.

Centre for Renewable Energy

The Centre for Renewable Energy's main objective is to increase the quality, efficiency and scope of education, research, development and innovation in renewable energy in Norway. To achieve this, the Centre coordinates existing activities and establishes new activities at its member institutions to promote knowledge development and implementation and use of renewable energy sources and technologies.

The Centre for Renewable Energy was established in 2004 as a cooperative effort between NTNU and SINTEF. In December 2005 IFE became an equal partner and in the beginning of 2011 the University of Oslo (UiO) will join the centre.

At NTNU, the Centre is located under the umbrella of the Energy and Petroleum – Resources and Environment strategic area. At SINTEF and IFE, the centre is incorporated in the management and at UiO it will be affiliated with the Faculty of Mathematics and Natural Sciences. The internal network of NTNU, SINTEF and IFE comprised more than 250 scientific researchers and 150 PhD students within the field of renewable energy in 2010.

The strategy of the Centre for Renewable Energy is:

- **Influential:** The Centre works to inform decision takers, politicians and the industry to strengthen research and development of renewable energy in Norway.
- **Networking and coordination:** The Centre facilitates better cooperation and coordination between central research institutions and areas in Norway and internationally. SFFE offers a common meeting ground for research institutions, industry and government.
- **Dissemination and information:** The Centre spreads information and contributes to increased knowledge about renewable energy in Norway.
- **Recruiting:** The Centre advocates renewable energy as a desired study topic and career for young people.

Main results 2010

- The first "Renewable Energy Research Conference" (RERC) was held in Trondheim. The conference was the largest research conference on renewable energy in Norway in 2010, and attracted more than 400 participants from 15 different nations. The next RERC will be organized in 2012.
- SFFE has long had the desire to expand its partnership with the University of Oslo and in December 2010 it was decided that the Faculty of Mathematics and Natural Sciences at UiO will become a partner in the centre.
- Together with the Norwegian Climate Foundation in Bergen, SFFE initiated a consensus process to discuss a framework necessary for establishing an offshore wind industry in Norway. A first workshop will be held in March 2011 and other actors such as the Federation of Norwegian Industries have been included in the planning process.

Gas Technology Centre

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 that 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 expertise, which encompasses the entire value chain from the energy source to the end user.

The mission of GTS is to act as a common interface for 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.

Main results 2010

IEAGHG International CCS Summer School
The summer school was arranged 22-28 August by GTS in collaboration with BIGCCS, SUCCESS and UNIS in Spitsbergen, Svalbard. Fifty-six students from 32 countries, and 30 expert lecturers and mentors attended the one-week programme.

Success in EU's Hydrogen programme
Four new EU projects started January 2010, with funding from the Fuel Cells and Hydrogen Joint Undertaking (FCH JU) as well as substantial national support from the Research Council of Norway and Transnova. Three new projects were successfully evaluated under the FCH JU and will commence January 2011.

Gas Technology Activities 2009 report
The report provided an overview of the ongoing activities in gas technology at NTNU and SINTEF, and was widely distributed at conferences, meetings and other events to promote the NTNU/SINTEF gas community.

Internationalization activities
Visits and participation in delegations to Brazil, Japan and USA were made to promote existing and new partnerships in natural gas processing, hydrogen and carbon capture and storage. Further details are provided in the GTS Annual Report 2010, found at **www.ntnu.no/gass**


GTS management: NTNU's director of GTS, Professor Hilde J. Venvik (left) and SINTEF's director of GTS, Dr. Maria Barrio

Petroleum Centre for Better Resource Utilization

Background

In September 2004, NTNU's Board of Directors included the upstream petroleum area as a member of the Energy and Petroleum – Resources and Environment strategic area. In 2004-2005, a major effort was invested in developing a new strategic plan for petroleum exploration and production at NTNU. An important element of the development was 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 on 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:

- Discovery and Production
- 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. The current status is:

Major research programs

- ROSE - the rock seismic programme
- 4D seismic - reservoir simulation programme
- Improved oil recovery programme
- Subsea programme
- New drilling methods programme
- SFI-Smart Fields/Integrated Operations programme
- Unconventional oil recovery programme
- FME Subsurface storage of CO2
- SFI-Centre for Drilling and Wells for Improved Recovery (new)

Main results 2010

International academic collaboration
NTNU has a wide range of international partners in the petroleum area. Current key countries are Angola, Bangladesh, Brazil, Canada, France, Italy, Mozambique, the Netherlands, Nigeria, Russia, Spain, Ukraine and the USA. Close to 50% of the MSc and PhD students in exploration and production are non-Norwegian. Some of the collaborating institutions in 2010 were: Agostinho Neto Universidade (Angola), BUET (Bangladesh), Carnegie Mellon University (USA), EMU (Mozambique), Stanford University (USA), TU Delft (Netherlands), Pontifícia Universidade Católica do Rio de Janeiro (Brazil), CAMPINAS (Brazil), University of Oklahoma (USA), University of Central Florida (USA) and Mines ParisTech (France).

International Conference in Trondheim – ROSE10
The 6th international conference on Rock Physics and Seismic was arranged at NTNU on April 19-20, 2010. The conference included sessions on rock physics, time lapse and reservoir characterization, and imaging and inversion. Approximately 75 people participated in the conference. The conference was followed by a two-day short course in seismic imaging, by Paul Sava and Ian Jones.

International Conference in Trondheim – IO10
The 7th international conference on Smart Fields/Integrated Operations was arranged on September 13-14, 2010 by the Centre for Integrated Operations (SFI) in Trondheim. The theme of the conference was Science and Practice, and presentations were made by academia and industry from all over the world. There were approximately 280 participants. Rector Torbjørn Digernes opened the conference. The conference is organized annually, and the next conference will be in September, 2011.

International educational support
The Petroleum Department has established several programmes to support petroleum education in oil-producing developing countries. Current programmes include Bangladesh, Mozambique, Angola, Nigeria and Venezuela. In 2010 Nigeria was added as a partner.

New graduates
In 2010, 83 MSc candidates graduated from the disciplines of Petroleum Engineering and Petroleum Geoscience. Thirty-five graduates were non-Norwegian. Among the Norwegian students around one-third had a one-year exchange period at a foreign university, primary in the USA, Canada, Brazil and Australia. A total of 7 PhD candidates defended their theses in 2009.

Publications
A total of 113 titles, including refereed journal publications, conference presentations, posters, etc. were published, of which 57 were in refereed journals. Under the Norwegian publication point system, a total of 44 points were registered in 2010, as compared to 44 in 2009 and 29 in 2008.

Successful midterm evaluation of the SFI Integrated Operation
The Research Council of Norway conducted their mid-term evaluation of the SFIs. The Centre for Integrated Operations passed the evaluation without any critical commentary.

Partner in a new SFI
The four key research players in petroleum research in Norway, SINTEF, IRIS, UiS and NTNU, joined forces in the establishment of a new research centre for Drilling and Wells for Improved Recovery. The centre was granted status as a SFI in December 2010.

New laboratories
A new laboratory for computer-aided lecturing was opened in 2010, which enhances the increased use of computer-aided lectures in the petroleum discipline.

Petrobras becomes a new industrial member in the Integrated Operations SFI
An important enhancement to industrial relations took place when the Brazilian state oil company, Petrobras, became an industry member of the Integrated Operations SFI in 2010.

Industrial collaboration
Close collaboration with the industry insures the relevance of NTNU's education and research and provides financial support for new facilities and research. Key industrial partners during 2010 were Aker Solutions, Bayerngas, BG Norge, Bridge Energy, BP, CGGVeritas, Chevron, ConocoPhillips, Det norske, DnV, E.ON Ruhrgas, ExxonMobil, ENI, FMC, Fugro-Jason, GdF Suez, IBM, Kongsberg, Lundin, Noreco, Petrobras, PGS Geophysical, Revus Energy, RockSource, Schlumberger, Shell, Spring Energy, Statoil, TOTAL, Wavefield Inseis, Wintershall, VNG. New agreements in 2010 included Petrobras (as a partner in the IO Centre and ROSE), Noreco, Wintershall, E.ON Ruhrgas, Bayerngas and VNG.

From the opening of the new centre for drilling and wells for improved oil recovery. From left: Kjell Arne Jacobsen, SINTEF, Aslaug Mikkelsen, UiS, Tora Aasland, Ministry of Higher Education and Research, Anna Aabø, IRIS, Sigbjørn Sangesland, NTNU

Centre for Energy and Society

2010 Overview

Energy and society as a research topic
The development of sustainable energy production and use are major challenges for Norwegian society, not the least related to cultural and political issues and the need to develop strategies for the social accommodation of new energy solutions. The Energy and Society research group will contribute to the strengthening of the knowledge base to develop strategies to construct a more environmentally friendly energy regime in Norway as well as internationally. This is to be achieved by analysing economic and cultural dimensions of energy use in dwellings and businesses, social aspects of the development of new energy technologies, and political and financial strategies to achieve a sustainable production and consumption of energy.

The interests of the Energy and Society research group are integrated with the overall efforts of NTNU's Energy and Petroleum – Resources and Environment strategic area. Within this strategic area, the research group collaborates closely with the Centre for Sustainable Buildings, wind, gas technology and renewable programmes. In this way, humanists and social scientists are engaged in state-of-the-art interdisciplinary research where much effort is put into exploring how the interdisciplinary collaboration may be made even more productive.

Mainly, the Energy and Society research group frames its research by drawing on the field of science and technology studies (STS) and studies of science, technology and innovation (STI). This means that project researchers discuss broader theoretical concerns related to technology policy, social shaping of technology, innovation, design/user interfaces, domestication, social learning, and transition management. Thus, the research groups try to balance its efforts to participate in interdisciplinary interaction with architects and engineers, and also to contribute to the humanistic and social science understanding of phenomena related to sustainable use of energy and design of sustainable energy systems.

The research areas covered by the Centre include:
- 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

Strategic goals
The strategic goals for the Centre for Energy and Society are focused on four areas that we see as particularly important in order to be excellent, relevant and visible in the years to come. In short these strategies are about having a large portfolio of externally funded interdisciplinary projects, improving the dissemination and publication activities and to enhance our understanding of the different needs for knowledge, and to recruit and develop further (educate) excellent students.

People
- The following individuals are engaged in the activities of the centre:
- Three professors and three associate professors
- Two researcher scientists
- Four postdocs
- Nineteen PhD students
- Coordinator (CenSES)

We have also been awarded research funding for one PhD student and three postdocs in 2011.

Highlights from 2010

In 2010, the following projects with which we are involved were funded:
- SoRoSol – Socially Robust Solar Cells
- NORD-STAR
- ERA-net (Guidelines for the implementation of "Electric Road Transport" policies in Europe

The research group continued to grow in 2010. Five new PhD students and one postdoc were engaged, and one new, large project was initiated. We would like to highlight that in 2010 the Centre became a partner in a Nordic Centres of Excellence (NCoE) under the Nordic programme on "Effect Studies and Adaptation to Climate Change". The main objective of a NCoE is to create added value through Nordic cooperation and further increase the visibility and the scientific quality of Nordic research. The Nordic Centre of Excellence (NCoE) NORD-STAR aims to develop tools to help the Nordic

countries address the twin challenge of a warmer climate and the side effects of policy impacts. It is hosted by Aarhus University.

In the aftermath of the establishment of CenSES on April 5 2010, we have started a new project called "Developing policy and politics for environmentally friendly energy: Practice, innovation, learning and knowledge". Three new PhD students have been engaged to work on the project.

In 2010 the Centre for Energy and Society continued to lead one of the five work packages for the newly established Research Centre on Zero Emission Buildings (ZEB). The ZEB centre has as its vision to develop competitive products and solutions for existing and new buildings that will lead to market penetration of zero emission buildings. The Centre for Energy and Society will help to achieve this goal by contributing new knowledge about a) the use and operation of zero emission buildings and b) the deployment of this construction approach. The participation of several of our researchers in the cross-disciplinary project "Towards Carbon Neutral Settlements – Processes, Concept Development and Implementation", is particularly important in this regard, because the practical aim is to develop Brøset into a good neighbourhood where the inhabitants' CO2 emissions are reduced drastically through planning as well as through technical and social solutions. In the spring of 2010 we participated in the organization of two workshops with ZEB's industry partner on the use and operation of zero emission buildings. We co-organized the panel on zero emission buildings at the RERC conference in Trondheim, and also co-hosted thematic sessions at the 4S annual meeting in Tokyo and the 2010 EASST conference in Torino.

We arranged or co-hosted 12 sessions, seminars and workshops in all during 2010, of which the most important events were:

- Actor-network theory and energy studies, international workshop, December 2010
- RERC, panel on Social Studies of Energy, June 2010, Trondheim (80 participants, international outreach)
- Workshop on Transition Strategies I, Trondheim, June 9 (NTNU, UiO)
- CenSES Innovation Forum for FMEs, August, Trondheim
- Workshop on Transition Strategies II, Trondheim, October 5, (DTU, NTNU, UiO)
- Workshop, Joint Research Centre, Jiao Tong University, Shanghai May 2010

Among academic achievements, we would like to highlight the following articles

- Berker, Thomas and Helen J. Gansmo. Paradoxes of Design: Energy and Water Consumption and the Aestheticization of Norwegian Bathrooms 1990-2008. Sustainable Development 2010; Volume 18 (3) pp. 135-149.
- Berker, Thomas. 2010. "Dealing with uncertainty in sustainable innovation: Mainstreaming and Substitution." Int. J. of Innovation and Sustainable Development 5:65-79
- Berker, Thomas and Helen J. Gansmo. Sustainable urbanization? Norwegian cabin culture in transition. Journal of Tourism and Cultural Change 2010; Volume 8 (3) pp. 172-182.
- Ryghaug, Marianne and Tomas M. Skjølsvold. The Global Warming of Climate Science: Climategate and the Construction of Scientific Facts. International Studies in the Philosophy of Science 2010; Volume 24 (3) pp. 287-307.
- Solli, J. (2010). Where the eagles dare? Enacting resistance to wind farms through hybrid collectives. Environmental Politics, 19 (1), 45 - 60.
- Sørensen, K. H. (2010). Det norske samfunn: Et innovasjonssystem? In I. Frønes & L. Kjølsrød (Eds.), Det Norske samfunn (pp. 517 s.). Oslo: Gyldendal akademisk.

This has also been an active year regarding dissemination. During 2010 we published 8 articles in journals and edited collections, presented 17 scientific conference papers along with13 other dissemination activities. We produced 5 CenSES newsletters.

Strategic Initiative "Green Innovation"

"Green Innovation" combines broad insights into energy and environmental issues with knowledge about innovation and implementation of technology. One main goal is to study how innovation processes, particularly barriers and driving forces, may help us adapt to, and mitigate, the major change in the energy picture that now lies ahead. The research focus includes strategy and innovation theory, economic growth and technological change, as well as system dynamics and optimization of activities operating together in value sequences.

Green Innovation has now reached a point where direct links are seen between dynamic feed-forward situations, and possibilities for large-scale change that will allow society to meet the energy-related changes ahead in an adaptive manner. Based on the theory of open thermodynamic systems, Prigogine (1997) tells us how systems away from equilibrium become mechanism-dependent, and how change takes the form of bifurcations in dissipative systems (autocatalytic systems with a flow of energy that maintains non-equilibrium and builds order; living organisms and cities are examples). The mechanisms involved in adapting to change are precisely situations of economic feed-forward, or in economic parlance, "increasing marginal utility". The task now is to think up these concrete systems and evaluate their economic robustness and path-dependent behaviour. As a concrete example, Green Innovation is studying the broad potential of dynamic thermal storage as a means of drastically reducing the requirement for energy for heating and cooling of buildings.

Highlights from 2010

- State secretary, Eli Blakstad, Ministry of Petroleum and Energy, opened the first part of the project "Active Dynamic Thermal Storage for Industrial Processes" (KMB) funded by the Research Council of Norway, ENOVA and Nord-Trøndelag County.

- "Technology and Economics Facing a Changing Energy World. System Dynamics and the Potentially Available Technologies", presentation and arrangement at the international symposium at Voksenåsen.

International Cooperation

All centres that are part of the strategic area have developed substantial international collaborative networks. On behalf of NTNU, the strategic area puts a strong emphasis on developing long-term strategic collaboration with selected universities in regions and countries where "Team Norway" wants to develop industrial cooperation, particularly the European Union, Asia (Japan, China and now India) and North America. These long-term cooperative efforts are shaped in part by the challenges posed by the different countries and typically involve several research areas and several centres. The strategic area remains active in building cooperative partnerships until the networks and projects between professors and an organization have been established.

We have an excellent collaborative relationship with the Research Council of Norway (RCN), which has been co-financing most of this strategic network development.

European Union

As a result of our systematic and strategic teamwork since 2003, NTNU and SINTEF have been able to establish a successful presence in the European Research Area during the development of the 6th and 7th Framework Programmes. Thus, we are involved in a substantial number of projects (see separate list) under the topics of Energy and Society, Energy in Buildings, Renewable Energy, Hydrogen and Fuel Cells, and Carbon Capture and Storage (CCS). NTNU/SINTEF's share of these EU projects amounts to approximately NOK 140 million.

ECCSEL - ESFRI
As described in the 2008 and 2009 Annual Reports, Norway was successful in getting our ECCSEL initiative included in ESFRI's new Road Map for 2008. (ECCSEL = "European Carbon Capture and StoragE Laboratory Infrastructure", ESFRI = "European Strategic Forum for Research Infrastructure"). This was a result of a long process, which started with the ENGAS project, where NTNU/SINTEF for the first time put laboratory infrastructure on our strategic agenda. ECCSEL involves 15 partners from 10 countries and the plan is to develop a pan-European integrated research infrastructure for CCS. This will involve an investment on the order of NOK 730 million in order to build 15 new unique laboratory installations in the years ahead. Of this, roughly NOK 210 million will be spent in Norway.

Since large investments and organizations are involved, the first part of any ESFRI project is to carry out a Preparatory Phase Project (PP). In close cooperation with our partners, and with Laboratory Director Morten Grønli as coordinator, we were able to submit our PP proposal on December 3, 2009. It should be emphasized that NTNU and SINTEF enjoy a very close working relationship and that there was active involvement both from Ministry of Education and Research and the Research Council of Norway in this effort.

It should be mentioned here that the Ministry already has granted NOK 185 million for rehabilitation of the laboratory buildings at NTNU to prepare for the ECCSEL installations.

- This close cooperation became decisive in 2010, when we had to work very hard at all levels, including the political, to win financing for our PP. But we succeeded, and we were able to start the four-year long preparation for ECCSEL on January 1, as planned. NTNU would like to express our gratitude to the Ministry and the Research Council, and we look forward to carrying out a successful PP.

This is by far the largest project that NTNU has coordinated, and we will use the opportunity to strengthen our ability to carry out larger projects.

The kick-off for ECCSEL with a first meeting of the general assembly and board will take place at the Test Centre Mongstad in Norway on February 9-10, 2011.

SEEIT – Strategic Partnership for Sustainable Energy Education, Innovation and Technology
As described in the 2009 Annual Report, the SEEIT Consortium reached the final round in the competition for a Knowledge and Innovation Community (KIC) in Energy. Because of the team spirit we developed through the application process, and the strong belief in the plans we have brought forward, the SEEIT family decided unanimously to form a consortium to carry out our original plans, i.e. to work together and take initiatives within research programs and education.

The SEEIT organization developed in 2010 consists of the following partners:
Universities: Aalto University, Albert-Ludwigs-Universität Freiburg, Copenhagen Business School (CBS), Delft University of Technology (TU Delft), NTNU, Politecnico di Torino (Polito), Technical University of Denmark (DTU), Technische Universität München (TUM). **Research Institutes:** ENEA (Italy), Fraunhofer Institute for Solar Energy and SINTEF.

The main objectives for the SEEIT partnership are:

- To become a global leader in accommodating the fast-growing demand for skilled experts in the area of sustainable energy by educating and training students and academic staff at an unprecedented scale.
- To accelerate the development and promotion of sustainable energy technologies by conceiving and implementing joint programmes for education, innovation and research in support of e.g. the SET-Plan.
- To become a central agent for significantly improving the quantity, quality, and the speed of implementation of sustainable energy innovations in established enterprises as well as in start-up firms.
- To work towards a long-term, durable integration of excellent education, innovation and research capacities across the European continent, in order to create a pan-European network of students, faculty staff, leading higher education and research institutions, and companies.

See: **www.seeit-alliance.eu/SEEIT**

The main areas of interest for SEEIT are bio energy, wind energy, solar energy, energy efficiency and energy systems, i.e. a strong team on sustainable energy. In 2010 we worked on the organizational aspects of the group, and began planning of activities.

- The first Steering Committee Meeting was organized in Frankfurt.
- The first SEEIT Innovation Camp for students took place August 30 – September 3 at Aalto University in Finland.
- Two offshore wind seminars were organized at TU Delft on September 22 and December 2. The goal was to develop and launch a Master's programme on offshore wind with TU Delft, DTU and NTNU as partners.
- First solar workshop organized at Fraunhofer ISE and ALU Freiburg September 30.

Prorector Johan Hustad represents NTNU in the Steering Committee and a SEEIT network has been developed at NTNU.

Japan

Cooperation with the Kyoto International Forum for Environment and Energy (KIFEE) strategic network was further developed in 2010, with support from the Research Council of Norway and Innovation Norway (IN) in Tokyo. NTNU and SINTEF also participated in delegations and workshops organized by Innovation Norway, and also welcomed important visitors from Japanese research and industry.

KIFEE, which was founded by Professor Yasuhiko Ito, was originally created by the universities in the Kyoto region, and aimed to develop an international arena for strategic cooperation between universities working to develop a sustainable society, inspired by the Kyoto Protocol. As a fruitful result of the Bilateral Agreement on Technological Cooperation between Japan and Norway signed in May 2004, NTNU and other Norwegian universities were invited to participate in KIFEE as a result of long-lasting and good relations between universities in the Kyoto region and NTNU.

KIFEE has developed into a platform and arena for strategic research cooperation that targets process engineering, electrochemistry and advanced inorganic materials, advanced biological materials, education in energy and environment and advanced sciences and technologies for environment and energy. Since the first KIFEE Symposium held in Kyoto in October 2004, five series of symposiums have been organized successfully in Japan and Norway. The response in both countries has been exceptionally good. The presence of more than 40 Japanese participants at the second and fourth KIFEE meetings in Norway in 2006 and 2009, and a similar attendance from Norway at the third and fifth symposiums in Japan in 2007 and 2011 reflect the substantial commitment from both countries. KIFEE has become not only a unique scientific network involving many universities, research institutes and enterprises in Japan and Norway, but also an accelerator of the extensive collaboration and cooperative projects between Japan and Norway.

KIFEE has as its goal to serve as a strategic forum and a means of building professional relationships that promote education and research collaboration between Japan and Norway.

The support of the Research Council of Norway and Innovation Norway has been crucial for the development of KIFEE so far, and we will work hard in 2011 to give Japan and KIFEE a central place in the realization of RCN's new strategy for International Cooperation.

The planning work for the next 2011 KIFEE Symposium started in 2010. Thus an "education delegation" from NTNU visited Doshisha University in June 2010 to organize workshops with colleagues and start the preparations of their parallel session at the next KIFFEE Symposium.

China

The development of long-term strategic cooperation with China in the energy sector started in 2004 in close cooperation with Innovation Norway and the Research Council of Norway. At that time, Professor Harald Høyem from the Department of Architectural Design, History and Technology had already developed a long-term partnership with Xi´an University of Architecture and Technology. The following strategy for the further development of the relationship was adopted, concerning selected universities and areas for cooperation:

- Tsinghua University, Beijing
  Energy Conservation in Buildings; Energy and Society; Hydrogen/Fuel Cells; Renewable Energy (wind, solar, bio); Carbon Capture and Storage, Energy systems
- Shanghai Jiao Tong University
  - Gas Technology (LNG), Gas Engines, CO_2 as working fluid, Carbon Capture and Storage; Renewable Energy; Energy Systems
- Chongqing University
  - Renewable energy

The visit of the large NTNU centennial delegation to China in connection with EXPO 2010, headed by the rector, gave the energy family an excellent opportunity to follow up on the development of our contacts. TSA Energy recruited an energy team of 10 professors, which visited our partner universities from May 25 to June 3. The aim was to contribute to the development of Joint Research Centres with Shanghai Jiao Tong University and Tsinghua University, and to develop contacts and cooperation on Renewable energy at Chongqing University. The decision was taken in 2009 to use Joint Research Centres as an instrument for the development of cooperation, after discussions and communication with the Chinese Embassy. Before our journey, the Chinese Ambassador visited NTNU on May 13 to be informed about our preparation work.

Tsinghua University (THU)
The cooperation with Tsinghua University has already started in the "Energy in Buildings" discipline, since THU is already a partner in the NTNU FME on "Zero Emission Buildings" (ZEB). They are also partner in the LinkS project on sustainable energy strategy, which is a part of CenSES.

THU – NTNU workshop at Tsinghua University

With the rector as a door-opener we were able to organize a THU-NTNU New Energy Workshop on June 1 during our visit at Tsinghua Campus. The delegation from THU was headed by Professor Jianlong Wang, Vice-director, Institute of Nuclear and New Energy Technology (INET) and the delegation from NTNU was headed by Rector Torbjørn Digernes. During the successful meeting we jointly agreed to develop a Joint Research Centre, with an emphasis on "Renewable Energy", "Carbon Capture and Storage", "Hydrogen Energy Technology" and Energy System Analysis and Sustainable Energy Studies".

During the autumn of 2010 we have worked with THU to develop a text for an agreement on a Joint Research Centre on Renewable and New Energy between our two institutions, which has been approved by both NTNU and INET. However, the approval from Tsinghua University has been delayed. The goal is now to sign the agreement before the summer of 2011.

Shanghai Jiao Tong University (SJTU)
Thanks to efficient cooperation and preparations by both SJTU and NTNU's top management, we were able to bring forward an agreement on a Joint Research Centre on Sustainable Energy between SJTU and NTNU before our visit. This made it possible to organize a signing ceremony at the main building of the SJTU campus on May 26, where the agreement was signed by SJTU President Jie Zhang and NTNU Rector Torbjørn Digernes (see picture). The Secretary of State at the Ministry of Research and Education,

Kyrre Lekve and representatives of the Research Council of Norway participated in the signing ceremony.

The main areas addressed by the JRC are:
- **Gas technology** to support the utilization of natural gas to substitute for coal (LNG technology – Distributed CCHP)
- **Carbon Capture and Storage (CCS)** to reduce CO_2 and other greenhouse gases – Use of CO_2 as the working fluid
- **Renewable energy** (solar, wind, ambient)
- **Energy use in Buildings/Zero Emission Buildings** (energy efficiency)
- **System analysis and optimization**

The contact persons responsible for the development of the JRC are Professor Ruzhu Wang, SJTU and Professor Arne Bredesen, NTNU.

On Friday May 28, we were able to hold the first SJTU-NTNU JRC workshop with 18 participants, where 16 presentations in selected areas were given by professors from SJTU and NTNU.

Chongqing University (CQU)
On May 31, an NTNU delegation headed by Prorector Johan Hustad visited the College of Power Engineering at Chongquing University. Sixteen people attended the meeting (10 from CQU and 6 from NTNU) where information about ongoing activities was shared by the two organizations. The following areas were identified as possible areas for cooperation:
- Bio energy
- Solar energy
- Fuel Cells (biological)
- Enhanced heat transfer
- Refrigeration and air conditioning

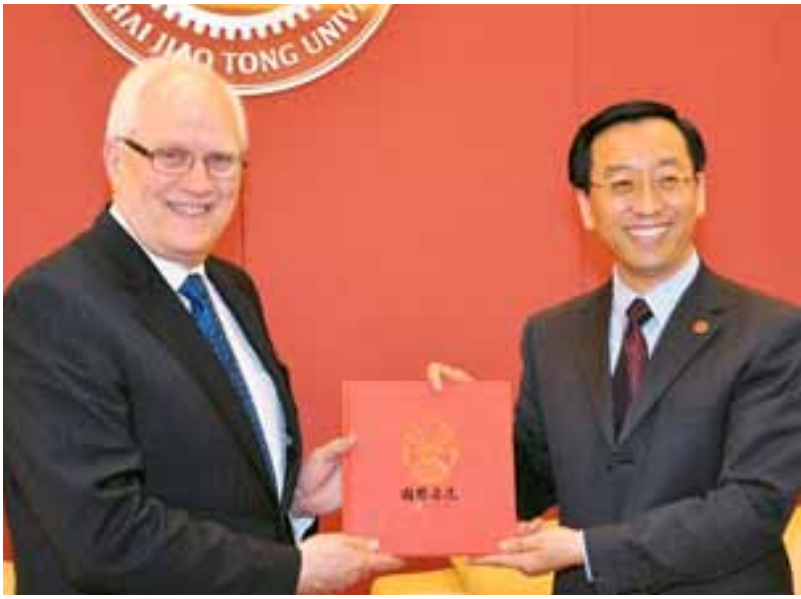
These possibilities will be pursued in 2011.

Research Council of Norway Seminar at the Norwegian Pavilion at EXPO May 21-22
The Research Council of Norway organized a successful seminar entitled "Developing sustainable energy for the future – R&D collaboration for new energy solutions". The seminar addressed 4 FME-related main topics:
- Carbon Capture and Storage
- Offshore wind technology and innovative concepts
- Advanced solar cell technology
- Sustainable hydropower development

More than 50 presentations were given by invited Chinese and Norwegian speakers. Since FMEs were the main target, NTNU and SINTEF participated heavily, both in the planning and carrying out of the seminar.

Polar bear tracks – an eye catcher in the Norwegian Pavilion at EXPO 2010 (sponsored by NTNU and SINTEF)

Other activities involving China in 2010
The Research Council of Norway has allocated money for project planning of research cooperation between China and Norway. We developed two project proposals to finance preparation workshops in China and Norway, with the specific goal to bring forward plans for the long-term development of each JRC. We were successful in achieving a total grant of NOK 850 000 for the two processes. NTNU will cover an equal amount from the budget of TSA Energy. These allowances will be of utmost importance for the successful start-up of the JRC. Once again the Research Council of Norway has played an important role in our international teamwork.



NTNU's Rector Torbjørn Digernes and SJTU's President Jie Zhang after signing the JRC-agreement

India

NTNU Leadership – Rectorate has put cooperation with India on the strategic map, and will bring a large delegation visit to India in February 2011. TSA Energy will participate and we have taken part in the preparations, where the research areas of the FMEs will be our main targets.

USA

In May 2004, the USA and Norway signed a MoU on research cooperation in the energy sector, with a special emphasis on CO_2 management, hydrogen fuel and new energy technology. NTNU has since then developed strategic collaboration with the Massachusetts Institute of Technology (MIT) and the University of Maryland.

Massachusetts Institute of Technology (MIT)
The development of our strategic cooperation with MIT started in 2002 based on the personal networks of the former director of Norsk Hydro, Rolf Marstrander. In 2004 we were able to initiate the energy system project TRANSES (Alternatives for the Transition to Sustainable Energy Systems in Northern Europe), which involved Norsk Hydro, Statoil, Shell, Statsbygg, Enova, Statkraft and Statnett as sponsors, and MIT, Chalmers, NTNU and SINTEF as research partners. The TRANSES project concluded in 2006 with a successful seminar.

Later in 2006 we were able to launch a "MIT-NTNU Gas Technology Program" based on the PPP model developed (PPP = Paired Professors and PhD students). This program involved three projects: "Gas transport systems", "CO_2 capture" and "Hydrogen Production", and was financed by Statoil and RCN. In 2008 and 2009, two new projects were started: "LNG technology" and "Offshore wind".

As a result of our close relationship, MIT is now also involved in the FMEs that concern "Offshore Wind" and "Zero Emission Buildings".

The cooperative effort is headed by a management group with representatives from Statoil, MIT and NTNU. The contact person at MIT is the Deputy Director of MIT's Energy Initiative, Professor Robert Armstrong. During 2011 we hope to be able to start up new projects.

University of Maryland (College Park)
Our cooperation with University of Maryland (UMCP) has progressed very well since the successful BILAT-financed Seminar on Energy and Environment at NTNU in November 2006, where 27 participants from UMCP's Joint Global Change Research Institute (JGCRI), the University of Oslo, IFE, SINTEF and NTNU agreed to cooperate on the following areas:

- Hydrogen/Fuel cells
- Combined Cooling Heating & Power
- Reliability and Safety
- Energy System Analysis

We have cooperative projects with the university in two areas, hydrogen technology and energy system analysis. A large KMB project, LinkS – "Linking Global and Regional Energy Strategies", was begun in 2009. This project involves NTNU/SINTEF, University of Maryland and the Joint Global Change Research Institute (JGCRI) in the USA, as well as Tsinghua University in China.

Transatlantic Science Week 2010
The annual Transatlantic Science Week has developed into an important meeting place for the development of scientific and technological cooperation between the USA, Canada and Norway. In 2010, the Science Week was organized in Washington on October 18-21, under the title of Global Challenges. The programme was organized around three challenges:

- Carbon Capture and Storage and Clean Energy
- Bio banks and Global health
- From Education to Innovation

NTNU participated with a solid delegation on energy and innovation, headed by Rector Torbjørn Digernes and Prorector Johan Hustad.

Headed by the Research Council, NTNU and SINTEF participated in planning and conducting a successful CCS workshop organized on October 20. Results from the cooperative effort between MIT and NTNU on CCS were presented. The cooperation between MIT and NTNU was also presented by Professor Robert Armstrong in the plenary session.

South Africa

A high-level CCS delegation from South Africa visited SINTEF and NTNU in May. As a result of the visit, Professor Olav Bolland and Trond Kvilhaug visited South Africa in December to plan a cooperative effort on CCS education with the University of the Witwatersrand in Johannesburg, South Africa. A proposal has been forwarded to NORADS EnPe programme.

A delegation of 11 from South African government departments, academia, research institutes, industry and media made a "Norway Carbon Capture and Storage Capacity Building Visit" from 1–8 May 2010. The purpose of the visit was to look for possible cooperating partners on CCS. The South African delegation expressed a strong interest in working with NTNU on CCS at a post-graduate level. Thus, an application for a pilot project was made and approved, leading to a visit by NTNU representatives to the University of the Witwatersrand, in December 2010. The pilot project runs through March 2011 and if successful, will form the basis for an application for a 2-year master's programme. A master's programme may in turn lead to permanent relations and cooperation between Norway and South Africa on education, research and industrialization of CCS developments. The Royal Norwegian Embassy in Pretoria strongly supported the idea of developing further cooperation between South Africa and Norway on educational and research activities related to CCS.

The Balkans

Over the years, NTNU has been developing cooperative networks with universities in the Balkan countries on energy education. In 2010 NTNU was able to launch a new large collaborative project, "HERD Energy", aimed at developing and establishing internationally recognized MSc study programmes in "Sustainable Energy and Environment", with the following participating institutions: the University of Belgrade, Belgrade, Serbia; the University of East Sarajevo, Lukavica, Bosnia and Herzegovina; the University of Sarajevo, Sarajevo, Bosnia and Herzegovina; the University of Tuzla, Tuzla, Bosnia and Herzegovina; the University of Zagreb, Zagreb, Republic of Croatia; Sør-Trøndelag University College, Trondheim; and New Energy Performance AS, Kjeller.

International cooperation Petroleum (BRU)

As can be seen from the Petroleum Centre report, the petroleum community has developed an impressive cooperative network with a wide range of international partners that work with petroleum issues. The current key countries are Angola, Bangladesh, Brazil, Canada, France, Italy, Mozambique, the Netherlands, Nigeria, Russia, Spain, Ukraine and the USA.

What are the benefits of the Strategic Area arrangement?

- One of NTNU's greatest assets is that it is home to a wide range of disciplines in technology, society and the humanities. The strategic area is a tool that enables this wide range of disciplines to be more useful to society.
- The strategic area brings top-level research groups from different disciplines together in goal-oriented teamwork to solve complicated problems that are of great importance to society. These complicated problems can only be solved through multidisciplinary teamwork, and we have the resources needed "in-house".
- By successfully planning and carrying out efforts together, we create better communication between disciplines. Walls between disciplines disappear, enabling the emergence of new multidisciplinary efforts. Because multidisciplinary research is critical to serving the future needs of industry and society, this approach attracts new partners and facilitates the commercialization of research results.
- By working on larger problem areas as one team with a common strategy, we also improve our visibility and impact, both nationally and internationally.
- The approach is also a benefit in winning funding from the Research Council of Norway, for the development of larger projects and programmes (it is easier for the Research Council to approve a ready-made project package than to try to put it together from individual pieces).
- We may also have a competitive edge in the European Research Area and strategic international cooperation.
- All this increases the opportunity for external funding of research projects, which has already been well demonstrated.

Above all, it is a great asset to have a strategic area that acts "on behalf of NTNU", and that our Rector is available and supports us.

Management in 2010

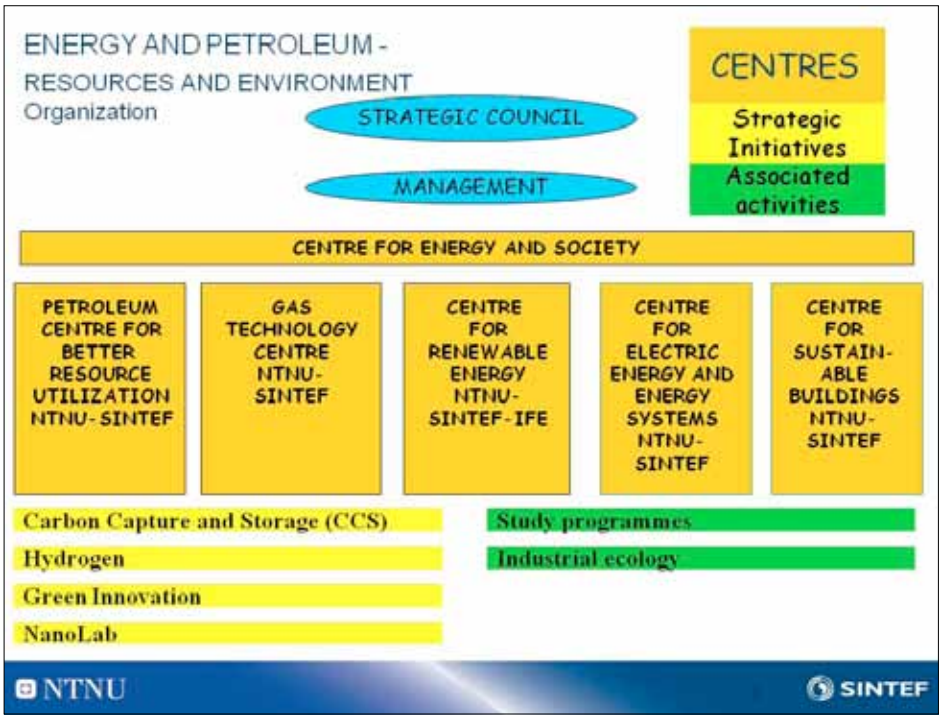
The figure below shows a schematic diagram of the strategic area's organization.

Centres:
- Centre for Sustainable Buildings: Professor Emeritus Øyvind Aschehoug
- Centre for Renewable Energy: Associate Professor Gabriella Tranell
- Gas Technology Centre: Professor Hilde Venvik
- Petroleum Centre for Better Resource Utilization: Professor Jon Kleppe
- Centre for Electrical Energy and Energy Systems: Professor Olav Bjarte Fosso
- Centre for Energy and Society: Professor Marianne Ryghaug

Strategic Initiatives
- "Green Innovation": Dr. Harald Gether
- "Carbon Capture and Storage": Professor Olav Bolland
- "Hydrogen Technology": Professor Hilde Venvik
- Study programme Energy & Environment: Professor Vojislav Novakovic
- Research Infrastructures: Laboratory Director Morten Grønli

Strategic area management:
- Director: Professor Arne M. Bredesen (arne.m.bredesen@ntnu.no)
- Associate director: Dr. Trond Kvilhaug (trond.kvilhaug@ntnu.no)
- Secretariat: Anita Yttersian (anita.yttersian@ntnu.no)

Strategic Council:
- Ingvald Strømmen, NTNU (leader)
- Anne Kathrine Slungård, Ungt Entreprenørskap Norge
- Bjørg Andresen, IFE
- Eli Aamot, Statoil
- Hans J Roven, NTNU
- Snorre Valen, Stortinget
- Nils Kristian Nakstad, Enova
- Ola Borten Moe, Stortinget
- Per Ola Ulseth, Skanska Norge AS
- Rolf Jarle Aaberg, Statkraft (has now left the council)
- May Britt Myhr, SINTEF Petroleumsforskning AS
- Sverre Aam, SINTEF Energiforskning AS



Schematic diagram of the strategic area's organization.

Visit us at **http://www.ntnu.edu/energy**

Research Council of Norway projects at NTNU and SINTEF

- Engineering Science for a Sustainable Future - Institutionally Based Strategic Programme (ISP) from the Research Council of Norway – 16 PhDs and postdoc fellowships related to "Energy from the North" and "Renewable Energy"
- Renewable strategies? Implementation and commercializing new energy technologies
- Building markets, shaping policy? The role of economics in energy policy and energy use
- Participation in IEA PVPS Task 10 Leadership of Subtask 2: Urban Planning, Design and Development
- Lifetime Commissioning for Energy Efficient Operation of Buildings
- Financial Engineering Analysis of Investment and Operations in Electricity Markets
- A new concept for power quality and reliability measurement and management
- Balance Management in Multinational Power Markets
- Offshore Wind Energy in Norway: Setting the Basis
- Deep Sea Offshore Wind Turbine Technology
- Offshore Renewable Energy PhD Pool
- Nanomaterials for 3rd Generation Solar Cells
- NSF-European Materials Cooperative Activity, "Nanostructured oxide thin films for organic/inorganic solar cell applications"
- Advanced sample preparation and characterization of fuel cell materials for increased fuel cell durability
- High Temperature PEM Fuel Cells Operating with Organic Fuels
- Improved efficiency and durability of PEM water electrolysers for hydrogen production
- Development of highly efficient nanostructured SOFCs integrating novel Ln(Nb,Ta)O4-based proton
- Optimal operation and control of chemical plants with natural gas feedstock (OPTGASS)
- BEEDIST - Basic energy efficient distillation technology
- Improved process design and operation of natural gas conversion

technologies

- Advanced reactor modelling and simulation
- Recovery of CO2 from high pressure gas with membranes
- Converting natural gas components to fuels and petrochemicals
- Fischer-Tropsch synthesis. Studies on the relation between catalyst properties and selectivity
- Development of CNF-polymer composites with high CNT loading
- Conversion of natural gas components in short contact time reactors
- New concepts in the catalytic dehydrogenation of propane
- Compact conversion of syngas to di-methyl-ether (DME)
- Large scale process for converting natural gas to hydrogen and high-value carbon
- Hydrogen production by Sorbent Enhanced Reforming
- Hydrogen production from natural gas in high temperature membrane reactors: Advanced catalysis from atoms to processes (MIT-NTNU)
- Carbon-supported core-shell electrocatalysts for oxidation of small organic molecules
- Template based synthesis of nanoporous metal-organic frameworks with high surface areas
- BIG CO_2, Phase 2
- Evaluation Methodology for Power Production with CO_2 Capture (MIT-NTNU)
- CO_2 Capture, enabling research
- Parameter optimization in preparation of membranes for osmotic processes
- Just Catch
- Modelling of particle deposition phenomena in heat exchangers
- Resource Optimization and recovery in the Materials industry Ringdalen
- Public Acceptance of Post-Carbon Strategies
- Capturing light in solar modules (IFE)
- E-Car, A strategy for electrification of road transportation in Norway
- Towards carbon neutral settlements – processes, concept development and implementation
- Professionalism and pragmatism? The management of environmental knowledge and interdisciplinarity in consulting companies
- Active dynamic thermal storage for industrial processes
- "A GREEN Sea", a 5-year project targeting new technologies and concepts for CO_2 and H2S removal from natural gas to avoid emissions and the use of harmful chemicals
- Conversion of natural gas and biomass to liquid fuels (Renergi + Statoil Vista + GTS)
- Environmental Sustainability (Renergi)
- Tailoring Intervention Instruments to Promote Emission Reduction in Norway (Norklima)
- Developing policy and politics for environmentally friendly energy: Practice, innovation, learning and knowledge.

EU Framework projects at NTNU and SINTEF

- PRIME Policies for Research and Innovation in the Move towards the European Research Area (Network of Excellence), **http://www.prime-noe.org/**
- PEP - Promotion of European Passive Houses, **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.cenerg.ensmp.fr/trees/**
- 3-NITY: 3-fold Initiative for Energy Planning and Sustainable Development at the 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_2 Capture and Storage (Coordinator)
- ENGAS: Environmental Gas Management Research Infrastructure (Coordinator)
- ENCAP: Enhanced Capture of CO_2 (Project manager)
- CO_2Remove: Geological storage of CO_2
- COACH: Co-operation Action within CCS EU-China
- CASTOR: CO_2 from Capture to Storage
- ULCOS: Ultra Low CO_2 Steelmaking
- INCACO2: International Co-operation Actions on CO_2 Capture and Storage
- CO_2GeoNet: Network of Excellence in Geological Storage of CO_2
- NATURALHY: Preparing for the hydrogen economy by using the existing natural gas system as a catalyst
- Membership in ZEP: The Technology Platform for Zero Emission Fossil Fuel Power Plants (two members)
- DECARBit: ("Decarbonize it") Focus on pre-combustion gas separation and hydrogen combustion
- CESAR: (Post combustion solvents and testing in demo plants)
- CAESAR: (SEWGS processes and materials testing)
- ECCO: European value chain for CO2
- CO_2-net: Thematic Network
- Preparatory Phase Project ECCSEL: European Carbon Dioxide Capture and Storage Laboratory Infrastructure (NTNU Coordinator)
- iCap – innovative CO_2 capture – EU FP7 (NTNU Coordinator)
- Membership in E2BA (Energy Efficiency in Buildings Associations)
- Member of EU network AERTO
- STAYERS, Stationary PEM Fuels Cells (FCH JU)
- RAMSES High Temperature Fuel Cells (FCH JU)
- HyLift-DEMO, Hydrogen & Fuel Cell powered Forklifts (FCH JU)
- H2movesScandinavia, demonstration of hydrogen vehicles and refuelling infrastructure in Oslo (GCH JU)
- SoRoSol – Socially Robust Solar Cells
- NORD-STAR
- ERA-net (Guidelines for the implementation of "Electric Road Transport" policies in Europe

Other international projects at NTNU and SINTEF

IEA – International Energy Agency

The Centre for Sustainable Buildings is participating in the following projects and programmes at 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/**

Tapir Uttrykk Nasjonalt sertifikat: 1660.

Annual Report for Energy and Petroleum 2010

NTNU – Trondheim
Norwegian University of
Science and Technology

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.

NTNU
NO-7491 Trondheim, Norway
Phone.: +47 73 59 50 00
Fax: +47 73 59 53 10

www.ntnu.no