

Annual Report 2008

Strategic Area
Energy and Petroleum
– Resources and Environment



What are the Strategic Areas at NTNU?

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

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Annual Report published by Energy and Petroleum - Resources and Environment

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About Energy and Petroleum–Resources and Environment

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

We need energy to provide essential human needs such as food, housing, clothing, 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 heat-trapping greenhouse gasses. At the same time several billion new world citizens will join us at the global dinner table. Providing **sufficient clean energy** to ensure a peaceful future and sustainable society for everybody is the largest challenge facing humankind today.

There will be an increasing demand for new knowledge, new technology, new solutions and new innovations to meet this global challenge. NTNU and SINTEF want to play an active and productive role in supplying scientific and technological information and innovations essential to the global transformation process we need to achieve 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 sources. A successful transition to clean and sustainable energy systems will depend on global innovations. Although the solutions that will be implemented will reflect local resources and conditions, they will emerge from the application of a mixture of key technologies, with which NTNU and SINTEF are actively working (see below).

Norway may be considered as an “energy country”. For this reason, government and industry have invested in the research that is

conducted in Trondheim, which has enabled NTNU and its research partner SINTEF to expand their energy-related research over the years. Today, nearly 1000 scientists are involved in efforts to create a cleaner energy future. This “family” includes roughly 170 professors and 350 doctoral students and post-doctoral researchers who are conducting fundamental energy-related research. NTNU also educates more than 250 master’s students each year, which in turn supplies the energy sector with highly qualified job candidates.

To be more useful to society and improve the way we meet future challenges, the strategic area has since 2000 developed an organization based primarily on goal-oriented multi-disciplinary research centres. This enables us to handle complicated problems that can only be dealt with through multi-disciplinary team-work. Today this organization (page 15) consists of the following six research centres:

- Centre for Sustainable Buildings
- Centre for Renewable Energy
- Gas Technology Centre
- Petroleum Centre for Better Resource Utilization
- Centre for Electric Energy and Energy Systems
- Centre for Energy and Society

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

- CO₂ Capture and Storage (CCS)
- Hydrogen technology
- Green Innovation
- NanoLab

NTNU and SINTEF have worked hard to

prepare for the hard and challenging work that lies ahead. Our main partners are the Norwegian government, the Research Council of Norway and the Norwegian energy industry.

Our vision is

“Sufficient and clean energy for a sustainable society”

The strategic area relies heavily on cooperation and coordination with the different NTNU faculties. The team work organization involves highly professional and unique research groups that handle strategically important areas in science and technology. There are more than 20 such research groups in our strategic area. The teams consist of NTNU professors, SINTEF researchers and PhD and master’s students, all of whom work in well-equipped, world-class laboratories. These research groups have been created by the faculties through allocation of personnel resources and laboratory investments. The development of new research groups to handle new technology areas thus relies on good communication between the Strategic Area and the faculties. The Faculty-Centre-Matrix below shows how our strategic area has developed such cooperative networks in almost all of NTNU’s faculties.

As a result of Norway’s location near the Arctic Basin, which contains large reserves of both renewable energy and natural gas, the NTNU-SINTEF team has given priority to the following main areas/strategies where we will contribute to the global innovation process. We want to develop new technology and solutions for:

- Efficient end use of energy
- Utilization of renewable energy sources
- Carbon Capture and Storage (CCS) to allow the use of fossil fuel and still reduce CO₂ levels
- Smart energy systems that integrate sources and end users in an efficient way
- Utilization of natural gas in an environmentally friendly way
- Hydrogen technology
- Better resource utilization and energy from the Arctic region

Faculty – Centre - Matrix		Contribution to Centres						
Faculty of:		Professors	BRU	GTC	CRE	ELES	Build	CES
Architecture and Fine Arts	5				X		X	
Engineering Science and Technology	86	X	X	X	X	X	X	X
Natural Sciences and Technology	32	X	X	X				
Information Technology, Mathematics and Electrical Engineering	31	X	X	X	X			
Social Sciences and Technology Man.	7	X						X
Humanities	6							X
Total	167							

Main events in 2008

- As of December 3, NTNU and SINTEF were active participants in 9 of 12 applications that made it to the final round in the national competition for funding of Centres for Environment-friendly Energy Research (CEER). These initiatives were:

- Biofuels Innovation Centre (BIC)
- BIGCCS Centre – International CCS research Centre
- Centre for Environmental design of Renewable Energy (CEDREN)
- Bioenergy Innovation Centre (CenBio)
- Centre for Sustainable Energy Studies (CenSES)
- Centre for Reduced Energy use through Advanced Technology InnoVations (CREATIV)
- Research Centre for Offshore Wind Technology
- The Norwegian Research Centre for Solar Cell Technology
- The Research Centre on Zero Emission Buildings - ZEB

This achievement was made possible thanks to four of our existing centres, the Centres for Renewable Energy, Gas Technology, Sustainable Buildings, and Energy and Society.

- In close cooperation with the Ministry of Education and Research and the Research Council of Norway, NTNU and SINTEF were able to bring forward a proposal for a new Pan-European research infrastructure – ECCSEL, which was officially included in the European Strategy Forum on Research Infrastructures (ESFRI) Road Map for 2008 at the European Conference on Research Infrastructures (ECRI) 2008 Conference Versailles on December 9.
- StatoilHydro renewed their contract as strategic partner in the Gas Technology Centre for 2008-2012
- Statkraft's Ocean Energy Programme was started in 2008. The programme will be headed by NTNU, and will include cooperation with the University of Uppsala and the Technical University of Denmark
- An agreement was signed among Aker Clean Carbon, SINTEF and NTNU to start up the 300 million NOK research programme called SOLVIt, to develop new cost-efficient technology for CO₂ capture.
- The new EnergyCampus North in Hammerfest started its education activities in August.
- The Centre for Renewable Energy has developed a joint "R&D Strategy for renewable energy" for NTNU-SINTEF and IFE, which has been printed in both Norwegian and English.
- The Gas Technology Centre and the Centre for Renewable Energy launched two international master's programmes, one on "Natural Gas Technology", which will involve EnergyCampus North, and one on "Innovative Sustainable Energy Engineering" together with other Nordic universities.
- The Gas Technology Centre participated with DNV and Aker Clean Carbon as an exhibitor at the 9th International Conference on Greenhouse Gas Control Technologies (GHGT-9) in Washington, DC on November 17-20.
- The fourth annual IO08 Conference (IO = Integrated Operation) was organized by the Petroleum Centre in Trondheim and attracted 280 participants (!)
- The Gas Technology Centre co-sponsored the Norwegian Hydrogen Seminar 2008, which was organized in Bergen on September 25-26, with 60 participants.
- NTNU, MIT and StatoilHydro conducted a successful workshop in Boston on October 28-29. The three groups agreed that the gas technology programme should be extended to include renewable energy.
- On April 15-16 a delegation from Tsinghua University visited NTNU and StatoilHydro in Trondheim. During a seminar and workshops, the groups agreed to develop a "Joint Centre on Renewable and New Energy", to handle the following areas: Biofuels, Acid Gas Capture, Hydrogen and Strategic Energy Systems.
- The fifth R&D Seminar on wind power was organized in January, with "The future is offshore?" as the theme.
- The Centre for Energy and Society organized a national seminar on research policy in June, and the international conference, "Towards post-carbon societies", in September.

Energy and Petroleum – Resources and Environment in 2008

2008 has been the most successful year in the history of the strategic area as a result of new national initiatives that were started in accordance with the national energy policy document called Energy21, as well as the Norwegian Storting's national climate agreement. Because we have developed a goal-oriented research organization, which is accustomed to making multidisciplinary proposals for thematic programmes, NTNU and SINTEF together were successful partners in six of the eight new Centres for Environment-friendly Energy Research (CEERs) that were awarded in February 2009. This means that we will start an eight-year research and innovation programme in 2009, in cooperation with industry partners and with a total budget of around 2 billion NOK. Our various research groups have also met with considerable success in other areas, as described below.

The award of the CEER money is our largest achievement to date and a ringing endorsement of the organization that we have developed since our beginnings in January 2000. The substantial planning process required of NTNU and SINTEF was carried out by the networks and research groups in the strategic area's multidisciplinary goal-oriented

centres (see page 15). They did the majority of the work, while the management, headed by NTNU's Rector and SINTEF's President, coordinated the process.

It is important to emphasize that the different centres have responsibility for their own strategies, action plans and activities, so this is where the bulk of activity takes place. We therefore refer the reader to the individual centre reports. The projects and contracts carried out during 2008 amounted to several millions of NOK. Thus the annual strategic grant from NTNU of around 2 million NOK proved to be a good investment.

The main task of the management is to develop overall goals and strategies and to ensure that there is teamwork and coordination throughout the different branches of the strategic area. We have worked strategically and systematically to improve our total output, as follows:

Based on the reports from the 2007 evaluation process, NTNU's Board decided internally to institute new working procedures to improve the operation of the university's six strategic areas. The strategic areas will con-

tinue to develop as modern action-oriented organizations, able to handle initiatives both in the interface towards society and industry (outside – in) as well as from researchers and research groups (inside – out).

We will also develop stronger communication and teamwork with NTNU's seven faculties, so that in the future we may develop unique research groups in most strategic areas. We will also develop a new set of goals and strategies that reflect and address in a better way public awareness of and political commitment to climate change issues, including the need for change in the energy system. We will also pay more attention to the innovation processes that may bring forward new solutions to energy issues, taking into account the role of technology development.

And last but not least, the Rector accepted our proposal to strengthen the management of the strategic area by recruiting a new assistant leader. Advertising and interviews were carried in September, and Dr.ing. Trond Kvilhaug accepted our offer and joined the team January 2009.

From Energy21 to Centres for Environment-friendly Energy Research (CEER)

As described in the 2007 Annual Report, NTNU and SINTEF participated actively and contributed substantially to the broad national effort to draft the new national strategy report "Energy21", which was delivered on time to the Minister of Petroleum and Energy, Åslaug Haga, on February 5. The report proposes that Norway increase its research and education efforts substantially so that it becomes the most environmentally friendly energy nation in Europe. At the same time, the Norwegian Storting came to a major climate agreement that is being used to set government policy. This, together with the increasing public awareness of climate change (such as through the Nobel Peace Prize), inspired the government and politicians to approve an historic increase of 300 million NOK in the annual budget for energy research in the Revised National Budget in April. These new financial resources were designated for the crafting of a new national energy revolution with a 10 to 20 year time frame. In accordance with Energy21 and the Storting's climate agreement the money is to be targeted to six strategic areas of national and global importance:

- Improved energy efficiency
- Climate-friendly power (including biopower)
- CO₂-neutral heating (including bioheat)
- An energy system to meet the needs of the future
- Frameworks and social analysis
- CO₂ capture and storage (CCS)
- Environment-friendly transport

In addition, Energi21 has been established as a permanent organization, responsible for the long-term realization of the national strategy. Both NTNU and SINTEF have representatives on the board that has been appointed.

The first major action decided by the Research Council of Norway (RCN) was to launch eight new Centres for Environment-friendly Energy Research (CEER). These centres involve universities, research institutes and industry in goal-oriented long-term research, education and innovation to create new solutions in the priority areas. Each centre will be funded for eight years, with an annual budget of 40 million NOK (50 % financed by the Research Council, 50 % by industry).



The decision to initiate these centres was made by the RCN's board by April and their call for proposals, published on May 23 laid out a very ambitious and demand-

ing application process divided into two stages: a first round with application date September 3 and a final round with application date December 3. The plan was to award five to six CEERs during the "Energy Week" on February 4, 2009.

NTNU and SINTEF put the CEERs on the top of their strategic agenda for 2008 and organized an "application organization" headed by the NTNU Rector and the SINTEF President. This organization consisted of the NTNU and SINTEF leaders of the CEER candidates proposed by the two organizations' various centres and research institutes. Two coordinators from NTNU and SINTEF were assigned to lead and coordinate the process. The most important job was to communicate efficiently with the Research Council so that information

at all times was distributed to and from the application teams.

The first application round saw the submission of 28 applications. NTNU and SINTEF were significantly involved in 17 of these, and three were headed by other institutions. The results from the first evaluation round were published in late September and showed that 17 applications had been cleared for the final round. NTNU and SINTEF were heavily involved in 12 of these. During the final round, two applications on the social sciences were merged into one. At the same time two applications had to be abandoned, so NTNU and SINTEF delivered 9 applications for final evaluation on December 3.

On February 4, 2009, eight proud CEER teams

received their CEER certificates from the Norwegian Minister of Petroleum and Energy, Terje Riis-Johansen – and **six were from NTNU and SINTEF**:

- **Norwegian Research Centre for Offshore Wind Technology (NOWITECH)**
- **CenBio – Bioenergy Innovation Centre**
- **The Norwegian Research Centre for Solar Cell Technology**
- **CEDREN – Centre for Environmental Design of Renewable Energy**
- **ZEB – The Research Centre on Zero Emission Buildings**
- **BIGCCS Centre – International CCS Research Centre**

Contact with the industry was handled by the application teams. It should be mentioned

here that because Energi21 had included all players in the national innovation team (industry, research, education and government agencies) in the making of the national plan, the response from industry was extremely good (some of them were waiting to be contacted). So there was no problems in obtaining the necessary financial support from industry. The 8 CEERs that are now starting up represent an industrial research investment of more than 1 billion NOK, evidence that industry has most certainly followed up its part of the commitment.

The Research Council of Norway should be highly complemented for the impressive job that it undertook, on target and on time.

From ENGAS to ECCSEL

In November 2007, NTNU and SINTEF, in close cooperation with the Ministry of Education and Research and the Research Council of Norway, were able to bring forward a new laboratory initiative called ECCSEL, proposed to be included in the European Strategic Forum for Research Infrastructure (ESFRI) Road



Map (see Annual Report 2007). ECCSEL (European Carbon Capture and Storage Laboratory Infrastructure) included partners from 10 European countries that together proposed building

an integrated Pan-European Research Infrastructure.

During the spring we received positive signals from ESFRI and were asked to develop a revised proposal by May 15 to clarify specific points. On August 20 NTNU and SINTEF were visited by the top leaders of ESFRI, Carlo Rizzuto and Hervé Peró. On September 11 we were invited to a contact and preparation meeting at the Ministry of Education and Research. And finally, on December 9, during the ECRI 2008 conference in Versailles, Carlo Rizzuto in his conference presentation announced officially that ECCSEL had been included in ESFRI 2008 Road Map.

The plans for the development of ECCSEL include investments on the order of 730 million NOK to build 15 new laboratory installations. Fully 210 million NOK will be spent in Norway. The new equipment will enable scientists in the European Research Area to help industry develop the next generation of CCS technology. The goal for this technology is to be so efficient and economic that society will use it to control CO₂ emissions from fossil energy sources.

Financed by the Research Council of Norway, NTNU and SINTEF started early in 2009 on a project to prepare for ECCSEL's start up in 2011.

It is a great honour for Norway and NTNU and SINTEF to be given the task of leading this prestigious project; to develop an integrated Pan-European Laboratory Infrastructure with common goals and strategies, and make it available for the large research programs that will be carried out within this area in the future. This would not have been possible without the strong and sound cooperation between the Ministry of Education and Research, the Research Council of Norway and NTNU-SINTEF. We look forward to further developing this team as ECCSEL becomes a reality.



NTNU's representatives Professor Arne Bredesen (left) and Laboratory Manager PhD. Morten Grønli at the infrastructure conference ECRI 2008 in Paris

Energy Campus North

The arctic may be an important energy region, but only if we explore and develop valuable energy sources in a sustainable way. This will require new skills in petroleum exploration, production, multiphase flow, integrated operations and liquefied gas technology, to mention only a few. The Norwegian government has put the arctic region on its agenda through the High North Initiative, and NTNU plans to contribute to achieving the initiative's ambitious goals.

As a result of our contributions to the development of the Snøhvit field, we were invited by StatoilHydro some years ago to use the new LNG plant at Melkøya in Hammerfest as an "educational facility" for our master's students. But we soon found out that this can go much further than we first envisioned. NTNU must be able to share the knowledge and skills we have developed over the years of working on energy education to the greater Hammerfest area. So we teamed up with University of Tromsø and the University Colleges in Narvik, Tromsø and Finnmark in 2006 to form Energy Campus North.

Our long-term goal is to develop an integrated programme in energy technology in Hammerfest, consisting of bachelor's and master's degrees, continuing education, and teacher training programme. The long-term goal is to increase the energy expertise in the region so that it is prepared for a future where energy and fisheries dominate the economy.

These plans were approved by the Ministry of Science in August 2007, and we received our first grant of 3.5 million NOK. Since then we have worked to build an organization in Hammerfest. ECN will plan the educational programme, based on existing courses and matched to local needs. Instruction will be

conducted partly by part-time teachers in Hammerfest, and partly by professors and teachers from the various partners. The extra costs involved in providing staff from Trondheim, Narvik and Tromsø available in Hammerfest must be covered by ECNs budget. The main advantage of this arrangement, however, is that we can take advantage of expertise and courses that have been developed over the years and make them available immediately.

The ECN is governed by an Interim Board. Here is a list of achievements to date:

- Recruited a director and established an office (www.energicampus-nord.no)
- Established an Industrial Contact Group to develop good networks and relationships with the substantial energy industry in Hammerfest – and organized two seminars.
- Planned the first education offerings – "Preparation year for bachelor studies" – "Forkurs"
- Secured 2009 budget (meeting with Ministry)
- Started the first ECN class in August, with 14 students
- Organized local support for NTNU's Specialization Course in "Gas Technology" for 35 5th year master's students in Hammerfest, with an excursion to the LNG factory at Melkøya

In 2009 we plan to start the first group of students in our bachelor's programme in energy. This will not be an easy task, and we are working on a long-term plan to have a "sustainable" energy study programme established in Hammerfest by 2015.

We have come very far in a short time, and we have enjoyed excellent cooperation with all

the stakeholders from the very start, including the Ministry of Education and Research, Finnmark County, Hammerfest city, and industrial companies headed by StatoilHydro. The further development of this team will be decisive in our long-term success.

EnergyCampus North is an initiative that has been fronted by NTNU's Rectorate, because it is an important strategic initiative that will demonstrate how NTNU can make its national expertise available for innovation 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

The "SmartBuild" project, financed by the Research Council of Norway, was completed and reported on in 2007. A website for the project was established in 2008 where an archive of reports and other results are available: <http://www.ntnu.no/em/smartbuild>. The sustainable building research represented by the SmartBuild project remains an important research area for both NTNU and the strategic area, so a research group was established after the project formally ended to develop new plans for continuing research.

That has meant 2008 has been a year of restructuring and work to establish new multidisciplinary research in the same tradition. The "Centre for Sustainable Buildings" was established in the spring of 2008, and a wider range of research units at NTNU and SINTEF were invited to join in. A joint memorandum for cooperation has been developed and a management group established.

In the spring of 2008, the Research Council of Norway invited R&D institutions to apply for funding to establish Centres for Environment-friendly Energy research, as a follow-up to the national strategic plan "Energy21" [see pages 9-10]. The SmartBuild researchers at NTNU and SINTEF joined forces in a major effort to develop a joint application for funding to establish a research centre for sustainable energy use in the construction sector. The most important actors in the construction sector – both private enterprises and public agencies – agreed to co-finance an ambitious research programme with the aim of "Zero Emission Buildings" (ZEB). The proposal was successful: The Research Council decided in early 2009 to support our plans to use more than 300 million NOK over the next 8 years for this purpose.

The ZEB centre will thus become a very important follow-up to the SmartBuild project. In

addition to the formation of national partnerships, the centre will involve cooperation with internationally well-known R&D institutions around the world (MIT and Tsinghua University).

NTNU funding for the building sector of the strategic area was used to support the application and establishment of the ZEB centre. Two PhD stipends have been earmarked for this R&D area and announced internationally.

Our main result for 2008 was thus that the core of the SmartBuild group has ensured that the R&D cooperation between NTNU and SINTEF in the field of energy use in buildings will continue for many years with increased intensity through the establishment of the ZEB centre. Our challenge now is to establish relevant activities for the other R&D units that are not directly involved in ZEB.



Main results 2007–2008

The main common task of the research group has been the production of the book "Smarte energieffektive bygninger" (Tapir Akademisk forlag, 2007) and the arrangement of the conference "Fremtidens smarte energieffektive bygg" where the main results of the project were presented. The conference drew 170 participants, and the interdisciplinary target group of the project was well represented at the conference, which was attended by architects, engineers, contractors, developers, public agencies, and NGOs.

Other interdisciplinary projects have been:

- The development of user friendly CO₂ heat pumps for heating and cooling of large buildings
- The development of a smart energy-efficient facade concept
- "Nettbygger" – A consultancy service for inter-disciplinary cooperation in the planning of smart energy efficient buildings, www.nettbygger.net
- Tools for integrated design and continuous commissioning

In addition, the SmartBuild project has produced the following tangible results:

- 22 papers in refereed international journals
- 58 peer-reviewed articles
- 7 books
- 48 presentations at international conferences
- 132 reports and presentations at national conferences
- 46 articles and presentations targeted at different user groups
- 16 dissemination actions targeted at the general public
- 9 features in mass media
- 5 new methods/models/prototypes
- 2 PhD and 3 Post Docs completed, 3 more PhDs to be completed in 2008
- At least 7 different companies have adopted new technologies and knowledge developed in the SmartBuild project

In 2008, the platform created by SmartBuild was used to develop a new Centre for Sustainable Buildings, which will be an important contribution to the new substantially increased research activity that will follow as a consequence of the Energy21 initiative and the Norwegian Storting's 2007 climate agreement (see above).

Centre for Electric Energy and Energy Systems NTNU–SINTEF

The research centre plays an active role in developing technology for production, transportation and utilisation of electric energy. The Gemini Centre unites the research activity at the Electric Power Department of NTNU and the Electric Power Technology and Energy Systems Departments at SINTEF Energy Research. During 2008, the centre has 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 renewal
- Over voltage calculations and insulation coordination

Generation, transformation 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

10th year anniversary for 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 a record high in 2008, with 142 new students, of which 48% were women.

Research

The NOWITECH (CEER) research centre, which is focused on offshore wind energy, has been established as a partnership between

NTNU, SINTEF and IFE in close contact with the Norwegian industry. Fifteen PhD projects have already been announced, of which four are focused on electrical topics. The centre is also helping to establish a new EU project, MARINA, with a focus on offshore platforms that would convert several energy forms (such as wind and waves) into electrical energy.

Our close cooperation with SINTEF Energy Research is carried out through the continuation of a GEMINI centre (for three more years).

Six PhDs defended their theses in 2008. We also recruited 16 new PhD students, mostly international students.

New personnel

In 2008 Marta Molinas from Paraguay became the first female professor at the Centre. Molinas completed her PhD studies in Tokyo, Japan, and worked at NTNU as a postdoc before accepting the professorship in 2008.

Centre for Renewable Energy NTNU–SINTEF–IFE (SFFE)

The main goal of Centre for Renewable Energy (SFFE) is to increase Norway's ability to provide teaching, research, development and innovation in renewable energy. This is being achieved by coordinating existing and establishing new activities at NTNU, SINTEF and IFE; pursuing the development of new knowledge; and implementing the utilization of renewable energy sources and energy technologies.

The Centre for Renewable Energy was established in 2004 and was first developed as a cooperative unit between NTNU and SINTEF. In December 2005 IFE became an equal partner in the centre.

SFFE is a part of the Energy and Petroleum - Resources and Environment strategic area, while at SINTEF and IFE, SFFE is considered to be a part of the management area.

NTNU, SINTEF and IFE's internal network on renewable energy is comprised of more than 250 scientific researchers and 75 PhD students.

In 2008, SFFE activities were divided into the following categories:

- Visibility and communication
- Market and project initiation
- Networking and international contact
- Coordination and updating
- Education and recruitment

The Centre for Renewable Energy's main strategies are:

- Expertise: NTNU, SINTEF and IFE together represent the largest centres of technological expertise in Norway. This should be exploited to advance renewable energy technologies. The centre will contribute to enabling NTNU – SINTEF – IFE and Norway to take a leading international role in the development of a number of sustainable energy technologies.
- Recruiting: Ensure that renewable energy is a desired study topic and career for young people.
- Cooperation: The centre will build on existing and expanded cooperation in education and research by promoting student and scientist exchanges and by taking part

in international research projects.

- Internationalizing: The centre should improve our international position and promote international cooperation.
- Profiling: The centre will promote renewable energy in the Norwegian media.



- Information: The centre will become an important resource for information on renewable energy technologies.

Some highlights from 2008

- The centre's R&D strategy for renewable energy was published and printed in both Norwegian and English.
- SFFE was strongly involved in the Energy21 process. Energy21 has established a broad joint strategy for innovation and research within the Norwegian energy sector. A special report was delivered to the Minister of Energy and Petroleum on February 5, 2008.
- The R&D seminar on wind power was arranged for the fifth time in January 2008, under the title "The future is offshore?". The seminar was very popular and con-

stituted a solid base for discussion and communication on the future's technology for offshore wind turbines.

- Statkraft's Ocean Energy Programme was established in 2008 and has had a successful start up. NTNU was selected to lead the programme, which also includes researchers at the University of Uppsala and the Technical University of Denmark.
- Substantial effort was invested in preparing applications for the new Centres for Environment-friendly Energy Research (CEER/FME). The process has received a lot of attention both from researchers and the public, and has created an opportunity for developing new contacts. SFFE has been a valuable platform for many initiatives. SFFE was involved through its owners in seven of

the ten applications in the last phase, and would like to play a coordinating role as the new centres are established in 2009.

- Several new research initiatives has been established under the RENERGI funding programme from the Research Council of Norway:
 - Public Acceptance of Post Carbon Strategies (NTNU)
 - Capturing light in solar modules (IFE)
 - E-Car, a strategy for electrification of road transport in Norway (SINTEF).

Gas Technology Centre NTNU–SINTEF

The Gas Technology Centre was established in 2003 and is the largest centre for gas technology research and education in Norway. The centre develops new knowledge and technology with the goal of promoting the efficient and environmentally friendly utilization of natural gas.

The objective of the Gas Technology Centre, NTNU-SINTEF is to increase the quality, efficiency and scope of gas technology education, research, development and innovation in Norway, by coordinating and establishing new cooperative efforts between NTNU and SINTEF.

This includes the following actions:

- Contribute to strategies for value creation and innovation in Norway based on natural gas, and for the extension of this effort in the international business development of Norwegian companies.
- Initiate larger programmes for knowledge development and innovation in the natural gas sector.
- Coordinate the strategic objectives, resources and activities at NTNU and SINTEF.
- Gas Value Chain R&D
- Increase the visibility, cooperation and market orientation of in the Norwegian gas cluster both domestically and internationally.

Research Areas

Approximately 300 people (researchers, professors, postdocs 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 Centre addresses technology in the entire value chain from source to end-user. Research areas include:

- CO₂ capture and storage
- LNG and gas to liquids (GTL) for the world market from the Arctic region
- Offshore fields development including sub-sea technology
- Industrial gas processing and gas products
- Production, storage and use of hydrogen
- Gas engines
- Infrastructure, and technological and economic optimization of gas value creation.

New Leadership

Professor Bjarne Foss and Dr. Nils Røkke have done a magnificent job by jointly heading the impressive development of the Gas Technology Centre since its start in 2003. They have now decided to move further to other positions in NTNU and SINTEF, and in 2008 Dr. Maria Barrio and Professor Olav Bolland were appointed as SINTEF and NTNU leaders respectively.

Some highlights from 2008

- Signed a new operational contract period for 2008-2012. StatoilHydro continues to support the Gas Technology Centre as a strategic partner. The Gas Technology Centre remains open to additional partners.

- Supported the European Carbon Dioxide Capture and Storage Laboratory Infrastructure (ECCSEL). ECCSEL has been officially included in the EU Roadmap for Research Infrastructures (ESFRI).
- Signed an agreement with Aker Clean Carbon, SINTEF and NTNU to start up the 300 million NOK research programme called SOLVit, to develop new cost efficient technology for CO₂ capture
- Established two new international master's programmes on gas technology with the involvement of the GTC.
- Contributed to the creation of a research-based educational programme for energy engineering at EnergiCampus Nord in Hammerfest.
- Co-sponsored the Norwegian Hydrogen Seminar 2008.
- Participated with the Centre for Renewable Energy at the SCAN-REF 2008 exhibition.
- Participated as an exhibitor at the 9th Conference of Greenhouse Gas Control Technologies Conference, jointly with DNV and Aker Clean Carbon.
- Helped in the preparation of two CEER proposals: BIGCCS and CESTRA.
- Involved in the preparation of a collaborative project proposal (iCAp) on Innovative Capture Techniques with the EU 7th Framework Programme
- Prepared for the 5th Trondheim Conference on CCS
- Strategic participation in R&D forums and initiatives

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

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 at NTNU in developing a new strategic plan for petroleum exploration and production. An important element of the development has been visits to and discussions with approximately 50 oil and gas companies, service companies, governmental agencies, organizations, and the Research Council of Norway. Based on these visits and on discussions at a seminar at NTNU in 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

Task forces in each area have subsequently been developing plans for activities to be started in order to enhance research activities.

Current major research programmes in exploration and production of petroleum

- Oil recovery from highly viscous oil reservoirs
- ROSE - the rock-seismic programme
- 4D seismic - reservoir simulation programme
- Improved oil recovery programme
- Seafloor separation programme
- Subsea programme
- New drilling methods programme
- Smart Fields/Integrated Operations programme (SFI)

Some highlights from 2008

International academic collaboration

NTNU currently has a wide range of international partners in the petroleum area. Current key countries are Angola, Azerbaijan, Bangladesh, Brazil, Canada, France, Italy, Mozambique, the Netherlands, Russia, Spain, Ukraine and the USA. Almost 50% of the master's and PhD students in exploration and production at NTNU are non-Norwegian. In 2008, new formal agreements of collaboration were entered into with the University of Calgary, the University of Alberta and Vancouver Island University, and StatoilHydro, in the area of oil recovery from highly viscous oil reservoirs. Some of the collaborating institutions in 2008 were: Agostinho Neto Universidade (Angola), ASOA (Azerbaijan), BUET (Bangladesh), Carnegie Mellon University (USA), EMU (Mozambique), Kyoto University (Japan), Stanford University (USA), TU Delft (the Netherlands) and Pontifícia Universidade Católica do Rio de Janeiro (Brazil).

International Conference in Trondheim – IO08

The 4th international conference on Smart Fields/Integrated Operations was arranged in Trondheim in October 2008 by the Centre for Integrated Operations (SFI). The theme of the conference was Science and Practice, and presentations were held by academia and industry from all over the world. Keynote speakers came from Saudi Aramco, Petrobras, the BG Group and Stanford University. There were approximately 280 participants at the conference,

which is organized annually. The next conference is scheduled for October, 2009.

Graduated candidates

Approximately 80 MSc candidates graduated in 2008 from the disciplines of Petroleum Engineering and Petroleum Geoscience. Around 35% of the graduates are non-Norwegian. Among the Norwegian students, approximately one-third spend a one-year exchange period at a foreign university, primary in the US, Canada, Brazil and Australia. Four PhD candidates also defended their theses in 2008.

Publications

A total of 95 titles, including refereed journal publications, conference presentations, posters, etc. were produced, of which 59 were in refereed journals. A total of 29 points were registered in the Norwegian publication point system, as compared to 44 in 2007 and 33 in 2006.

Industrial collaboration

Close collaboration with industry ensures the relevance of our education and research and provides financial support for new facilities and research. Key industrial partners during 2008 were Aker Solutions, BG Norge, Bridge Energy, BP, CGG, Chevron, ConocoPhillips, Det norske oljeselskap, DnV, Enterprise Oil (Shell), ExxonMobil, ENI, FMC, Fugro-Jason, GdF Suez, IBM, Kongsberg, Lundin, Petrobras, PGS Geophysical, Revus Energy, RockSource, Schlumberger, Shell, StatoilHydro, TOTAL and Wavefield Inseis



From the signature ceremony in Calgary between NTNU, University of Calgary, University of Alberta, Vancouver Island University and StatoilHydro.

Centre for Energy and Society

Sustainable energy production and use are major challenges for the Norwegian society, not the least as 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 contributes to the strengthening of our knowledge base to develop strategies to construct a more environmentally friendly energy regime in Norway as well as internationally. The centre analyses 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 as a way to achieve the sustainable production and consumption of energy.

Energy and Society research interests are integrated into the overall efforts of the Energy and Petroleum – Resources and Environment strategic area. The research group collaborates closely with the SmartBuild, 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 such 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 the studies of science, technology and innovation (STI). This means that the projects are

conducted in dialogue with broader theoretical concerns related to technology policy, the social shaping of technology, innovation, design/user interfaces, domestication, social learning, and transition management. Thus, the research groups tries to balance its efforts between participating in interdisciplinary interaction with architects and engineers on the one hand, and contributing to the humanistic and social science understanding of phenomena related to sustainable use of energy and design of sustainable energy systems on the other.

Research Areas

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.

Highlights from 2008

- In 2008, we succeeded in getting funds for two new projects from the Research Council of Norway:
 - Professionalism and pragmatism? The

management of environmental knowledge and interdisciplinarity in consulting companies

- Renewable strategies? Implementing and commercializing new energy technologies

- The research group has had a considerable growth in 2008. Five new projects have started in 2008 and five new PhD students have been engaged.
- Among intellectual achievements, we would like to emphasize the article "Miljøarkitekten: Dirigent eller deltaker?" in Nordic Journal of Architectural Research written by Gry Kongsli, Marianne Ryghaug and Knut H. Sørensen.
- Two PhDs graduated in 2008:
 - Robert Bye defended his PhD thesis in January: "Lærende bygninger – Nøkkelferdige brukere? Bruk, brukervedvirkning og energieffektivisering i yrkesbygg".
 - Asbjørn Kårstein defended his PhD thesis in December: "HyNor - den norske hydrogenveien? En studie av en stor teknopolitisk hybrid".
- In September 2008 the centre arranged the international conference: "Towards post-carbon societies". The environmental historian Naomi Oreskes from University of San Diego, California, presented the lecture: "Committed to Carbon? The U.S. Situation".
- 2008 has been an active year regarding dissemination. We have presented 25 scientific conference papers in addition to 19 other dissemination activities.

Strategic Initiative "Green Innovation"

The "Green Innovation" research effort combines insights into energy and environmental issues in a broad sense, with knowledge about innovation and implementation of technology. A 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.

Results in 2008

- Cooperation with trade unions and federations on implementation methods for sustainable energy as means towards meeting the financial crisis.
- Additional financial support for a Professor II position for Erik S. Reinert at NTNU.
- Participation in the project "Offshore Wind Energy in Norway: Setting the Basis" by the Research Council of Norway.
- Industrial and commercial development relating to sustainable energy, and construction of a new facility for investigation into active thermal storage (DTES/BTES) at

Mære – supported financially by NTE, Enova and the North Trøndelag County Council.

- Opening speech at the annual conference by the Ministry of the Environment and strategic discussions over implementation mechanisms of sustainable energy in their project "Fremtidens byer" (The Future's Cities").
- Interviews at NRK TV, NRK Radio and at TV Norge in regional settings.
- PhD thesis of Karstad, P: "Norwegian value creation beyond oil and gas - strategic opportunities in sustainable energy production".

ENGAS Research Infrastructure

NTNU and its technology transfer partner SINTEF have jointly developed an 8,000 square metre, 38 million Euro research facility, the **ENGAS** Research Infrastructure, where energy researchers work to find ways to clean up CO₂, NO_x, SO_x 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 in 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/>).



LNG production facility

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 collaboratives with selected universities in regions and countries where “Team Norway” wants to develop industrial cooperation, particularly the European Union, Asia (Japan and China) and North America. These long-term cooperative efforts are shaped in part by the challenges in the different countries, and typically involve several research areas and several centres. The strategic area remains active in building cooperative partnerships until the networks between professors and an organization have been established.

We have been very fortunate to have an excellent collaborative relationship with the Research Council of Norway (RCN), which is 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 list) in Energy and Society, Energy in Buildings, Renewable Energy, Hydrogen and Fuel Cells, and Zero Emission Fossil Fuel Power Plants. These EU projects today have a total NTNU-SINTEF budget of 20 million Euros.

By far the largest EU achievement in 2008 was the inclusion of ECCSEL, our “European Carbon Capture and Storage Laboratory Infrastructure” initiative, in the European Strategic Forum for Research Infrastructure’s (ESFRI) Road Map for 2008 (see more detailed description on pages 11-12).

Research Infrastructure initiatives (GHG-LAB)

To handle the further development of ENGAS, NTNU began an Integrating Activity (I3), which was comprised of 13 universities, research institutes and energy companies in eight countries. This team developed a proposal called “European Laboratories for Greenhouse Gas Reduction (GHG-LAB)”. The application included 17 laboratories, organized in four science areas.

The application passed an initial threshold and was referred to as the best CCS proposal, but was not funded because of budget limitations. However, developing the application gave us valuable experience with Integrating Activities, which will be very important in the development of ECCSEL.

European Institute of Innovation and Technology (EIT)

In addition to the framework programme projects, the strategic area has been involved in strategic activities related to European Institute of Innovation and Technology. With our substantial energy research and educational activities, it is natural for NTNU-SINTEF to want to be a partner in a Know-

ledge and Innovation Community (KIC) in the energy sector.

EIT is headed by a governing board of 18 members that was appointed on July 30. The board had its first official EIT seminar in Bratislava on November 24, where the members laid out plans and vision for the EIT and the Knowledge and Innovation Communities (KICs). The board also officially announced the three areas that have been selected for the first round:

- Sustainable energy
- Climate change mitigation and adaptation
- Future information and communication society

The call for KIC proposals was officially announced on April 2, 2009, with the deadline for submissions August 27, 2009.

Pilot project SUCCESS

To prepare for the development of the Knowledge Innovation Communities (KIC) from the European Institute of Innovation & Technology, the Commission initiated three pilot projects, where the main strategy is to strengthen the knowledge innovation triangle between academia, research institutes and

industry. NTNU and SINTEF were invited to participate as partners in a group brought together by TU Karlsruhe and contributed actively in bringing forward the application SUCCESS (Searching Unprecedented Co-operations on Climate and Energy to ensure Sustainability) in August 2007. SUCCESS was later selected as the only pilot project for the energy sector, and will be carried out in 2008 and 2009.

NTNU and SINTEF have participated actively in SUCCESS, to gain contacts and experience that will be important for our preparations in EIT. In 2008 we participated in five workshops and seminars, and shared our experience with our successful collaboration between the university, research institutes and industry.

KIC initiative

Because of the SUCCESS contacts, NTNU was invited to participate in the Core Group of a KIC initiative taken by TU Karlsruhe. We participated in the first Core Group meeting on October 17. Later we participated actively in the efforts to develop an application on "Sustainable Energy". The application group includes universities, research institutes and industrial companies from Germany, Switzerland, Belgium, the Netherlands, France, Spain, Portugal, Italy, Denmark, Sweden, Finland and Norway.

JAPAN

Supported by the Research Council of Norway (RCN) and Innovation Norway (IN) in Tokyo, collaborative efforts with the Kyoto International Forum for Environment and Energy (KIFEE) strategic network was further developed in 2008. Through the network, NTNU and SINTEF participate in delegations and workshops organized by Innovation Norway, and also receive important visitors from Japanese research and industry.

In 2006 NTNU and SINTEF signed a Memorandum of Understanding (MoU) to develop a research collaborative with the National Institute of Advanced Industrial Science and Technology (AIST), a prestigious Japanese research institute. As a part of this, a successful "AIST-Norway NanoTechnology Symposium" was organized at the Senri Life Center in Osaka on December 3, prior to the KIFEE Seminar in 2007.

The biggest event and "family reunion" in 2007 was the successful KIFEE Seminar, organized in Otsu near Kyoto, at Lake Biwa

beach, from December 4 to 7. More than 80 people participated, including a Norwegian delegation of 40 from NTNU, SINTEF and industrial companies.

NTNU was awarded the honour of organizing the next KIFEE Seminar in Trondheim in September 2009, and which will also include workshops on nanotechnology to further integrate aspects of the AIST-NTNU-SINTEF collaborative.

KIFEE, the "brainchild" of Professor Ito, is developing into a most successful arena for Japan-Norway cooperation on environment and energy. That is why we are very happy that the University of Oslo has joined the team. The group has decided it will include education on energy and environment as a part of its efforts, which means there will be workshop sessions on:

- Process Engineering
- Advanced Biological Materials
- Advanced Inorganic Materials
- Electrolysis Systems
- Nanotechnology
- Education on Energy and Environment

CHINA

As a result of systematic strategic work begun in 2004 and continued in 2005 and 2006, the following strategies have been developed concerning selected universities and areas for long-term cooperation.

- Xi'an University of Architecture and Technology
 - Sustainable Rural Development
- Tsinghua University, Beijing
 - Energy Conservation in Buildings; Energy and Society; Hydrogen/Fuel Cells; Renewable Energy (wind, solar, bio); CO₂ management;
- Shanghai Jiao Tong University (SJTU)
 - Gas Technology (LNG, Gas Engines, CO₂ as working fluid); Renewable Energy
- Chongqing University
 - Gas technology

Participation in Minister Tora Aasland's Official Delegation to China, November 2008

NTNU Pro Rector for Research and Innovation Astrid Lægneid and Professor Arne Bredesen participated in the Official Delegation when Minister of Research and Education Tora Aasland visited China in November 2008. The delegation visited two of NTNU's strategic partners, Tsinghua University and Shanghai Jiao Tong University.

Tsinghua University (THU)

The cooperation on Energy in Buildings has developed well, and Tsinghua University is now a partner in the CEER Zero Emission Buildings, as well as a partner in the new Links project on sustainable energy strategy.

In a follow-up to the high level visit by StatoilHydro in April 2007, a Joint Seminar and Workshop between the Institute of Nuclear and New Energy Technology (INET) of Tsinghua University (THU), NTNU-SINTEF and StatoilHydro was organized in Trondheim on April 15-16, 2008. There were 40 participants.

INET-THU and NTNU decided at the seminar to develop a "Joint Virtual Research Centre on Renewable and New Energy", with BioFuels, Acid Gas Removal, Hydrogen and Sustainable Energy Strategies as specific areas. A MoU between INET-THU and NTNU, with StatoilHydro as an industrial co-partner at the project level, was signed in October 2008, and a "New Energy Workshop" was planned in Beijing on March 30-31, 2009, co-financed by the Research Council of Norway.

Shanghai Jiao Tong University (SJTU)

Financed by the RCN, NTNU and SJTU organized a Seminar on the Utilization of Natural Gas in Shanghai in March 2007. A delegation of 14 participants from the Research Council of Norway, Statoil, Elkem and NTNU-SINTEF participated in the more detailed workshops. Altogether, 23 presentations were made at the two-day seminar. The successful seminar was concluded with a face-to-face meeting between SJTU, NTNU-SINTEF and Statoil, where the most promising specific areas of research were identified. A strategy document based on this meeting was drafted to enable further cooperative efforts, with priority given to:

1. LNG technology (including small-scale production and distribution)
2. Distributed energy systems - CCHP
3. Carbon dioxide capture and storage (CCS)
4. Carbon dioxide as working fluid
5. System analysis and optimization => Regional energy planning

The LNG technology cooperative effort has begun, but has been delayed, and so far only one PhD has started. However, we foresee new projects in 2009-2010.

SJTU will be involved as partner in the new Research Council of Norway project on

energy efficiency in industry (CREATIVE) that will start in 2009, and which is a part of the national Energy21 initiative.

Jostein Pettersen (StatoilHydro) and Arne Bredesen (NTNU) were invited to present a keynote speech at the prestigious "International Conference on Cryogenics and Refrigeration" organized by Shanghai Jiao Tong University in April 2008. The title of the presentation was "Research on natural gas liquefaction technology for the Hammerfest LNG plant".

USA

In May 2004, the USA and Norway signed a MoU on research cooperation in the energy sector, with special emphasis on CO₂ management, hydrogen, and new energy technology. NTNU has since developed strategic collaboratives with the Massachusetts Institute of Technology (MIT) and the University of Maryland.

Massachusetts Institute of Technology (MIT)

In 2002 NTNU started a strategic collaborative with MIT and its Laboratory of Energy and the Environment. 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 Hydro, Statoil, Shell, Statsbygg, Enova, Statkraft and Statnett as sponsors; and MIT, Chalmers, NTNU and SINTEF are research partners. The TRANSES project was completed in 2006 with a successful seminar.

In 2005 and 2006 we continued our expansion of the MIT-NTNU cooperative, based on the model of paired professors developed by our strategic advisors, Rolf Marstrand and Per-Erling Frivik. In the paired professor model, two professors and two PhD students or postdocs from MIT and NTNU work together on a common project. After a hectic preparation process we were able to officially start up the "MIT-NTNU Gas Technology Program" with a signing ceremony at the Research Council of Norway in August 2006.

The 18 million NOK programme consists of three fundamental projects related to "gas transport systems", "CO₂ capture", and "hydrogen production", and is now financed by StatoilHydro and RCN. This cooperation model has attracted a great deal of interest and attention, and it will be used as a template in the further development of NTNU's international cooperative efforts.

The programme organized a successful seminar at MIT on February 28, 2007, by which time Statoil and Hydro had already decided to develop the programme further by initiating more projects. Because of the merger between Statoil and Hydro this took time, but in the spring of 2008 a new project on LNG technology was accepted.

On the MIT side the responsibility for the programme has been moved from the Laboratory of Energy and the Environment to MIT's Energy Initiative, which is a new dynamic organization initiated by MIT's President Susan Hockfield. Robert Armstrong, who is Deputy Director of MITEI, is our contact person.

In January 17-18 2008, the Gas Technology Programme organized a seminar and workshop in Trondheim, where results from the various research projects were presented. In June, Robert Armstrong visited Trondheim, and StatoilHydro, MITEI and NTNU decided to extend the "Energy Programme" so that it also included renewable energy. This resulted in a seminar at MIT on October 28-29, to present and discuss ideas for cooperation. The Norwegian delegation was headed by StatoilHydro's Director of Research and NTNU's Rector. As a result of this seminar, MIT was able to enter the CEER process so that they are now partners both in NOWITEC and Zero Emission Buildings. Proposals for further paired professor projects in renewable energy will be considered in the spring of 2009.

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, the 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 (TRANSES)

As a part of the "Hydrogen/Fuel Cell" area, an application was submitted to the RCN in 2006 and was funded. Financing has now been awarded on US side, enabling specific cooperative efforts to begin.

As a part of the "Energy System Analysis" area, a proposal for a new project called LinkS was submitted to the RCN in June 2007. LinkS involves UMCP, JGRI, the University of Oslo (ProSus), SINTEF and NTNU, and was designed to be a follow-up to TRANSES. During the last part of the CEER process, LinkS was funded and will now also include Tsinghua University as a partner.

As can be seen from the BRU report, the petroleum family has developed an impressive cooperative network with a wide range of international partners in the petroleum area. The current key countries are Angola, Azerbaijan, Bangladesh, Brazil, Canada, France, Italy, Mozambique, the Netherlands, Russia, Spain, Ukraine and the USA.

Management 2008

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 us to harness this 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 planning and carrying out things together successfully, we create better communication between disciplines. Walls between disciplines are disappearing, 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 trying 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.

CENTRES:

- Centre for Sustainable Buildings NTNU-SINTEF: Professor Emeritus Øyvind Aschehoug
- Centre for Renewable Energy NTNU-SINTEF-IFE: Professor Johan E. Hustad
- Gas Technology Centre, NTNU-SINTEF: Professor Olav Bolland
- Petroleum Centre for Better Resource Utilization (BRU): Professor Jon Kleppe
- Centre for Electrical Energy and Energy Systems: Professor Robert Nilssen
- Centre for Energy and Society: Professor Knut H. Sørensen

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

STRATEGIC ADVISORS:

- Rolf Marstrander
- Per-Erling Frivik

STRATEGIC AREA MANAGEMENT:

- Leader: Professor Arne M. Bredeesen (arne.m.bredesen@ntnu.no)
- Co-ordinator: Dr Harald Gether (harald.gether@ntnu.no)
- Secretariat: Anita Yttersian (anita.yttersian@ntnu.no)

Research Council of Norway projects in 2007–2008

- 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 commercialising 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 electrolyzers 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)
- Storskalaprosess for konvertering av naturgass til hydrogen og høyverdig karbon
- 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 CO₂, Phase 2
- Evaluation Methodology for Power Production with CO₂ Capture (MIT-NTNU)
- CO₂ 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
- Renewable strategies? Implementing and commercialising new energy technologies
- Active dynamic thermal storage for industrial processes

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 CO₂ Capture and Storage (Coordinator)
- ENGAS: Environmental Gas Management Research Infrastructure (Coordinator)
- ENCAP: Enhanced Capture of CO₂ (Project manager)
- CO₂Remove: Geological storage of CO₂
- COACH: Co-operation Action within CCS EU-China
- CASTOR: CO₂ from Capture to Storage
- ULCOS: Ultra Low CO₂ Steelmaking
- INCACO₂: International Co-operation Actions on CO₂ Capture and Storage
- CO₂GeoNet: Network of Excellence in Geological Storage of CO₂
- 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)
- DECARBit: ("Decarbonize it") Focus on precombustion gas separation and hydrogen combustion
- CESAR: (Postcombustion solvents and testing in demo plants)
- CAESAR: (SEWGS processes and materials testing)
- ECCO: European value Chain for CO₂
- CO₂-net: Thematic Network
- ECCSEL: European Carbon Dioxide Capture and Storage Laboratory Infrastructure

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/>

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