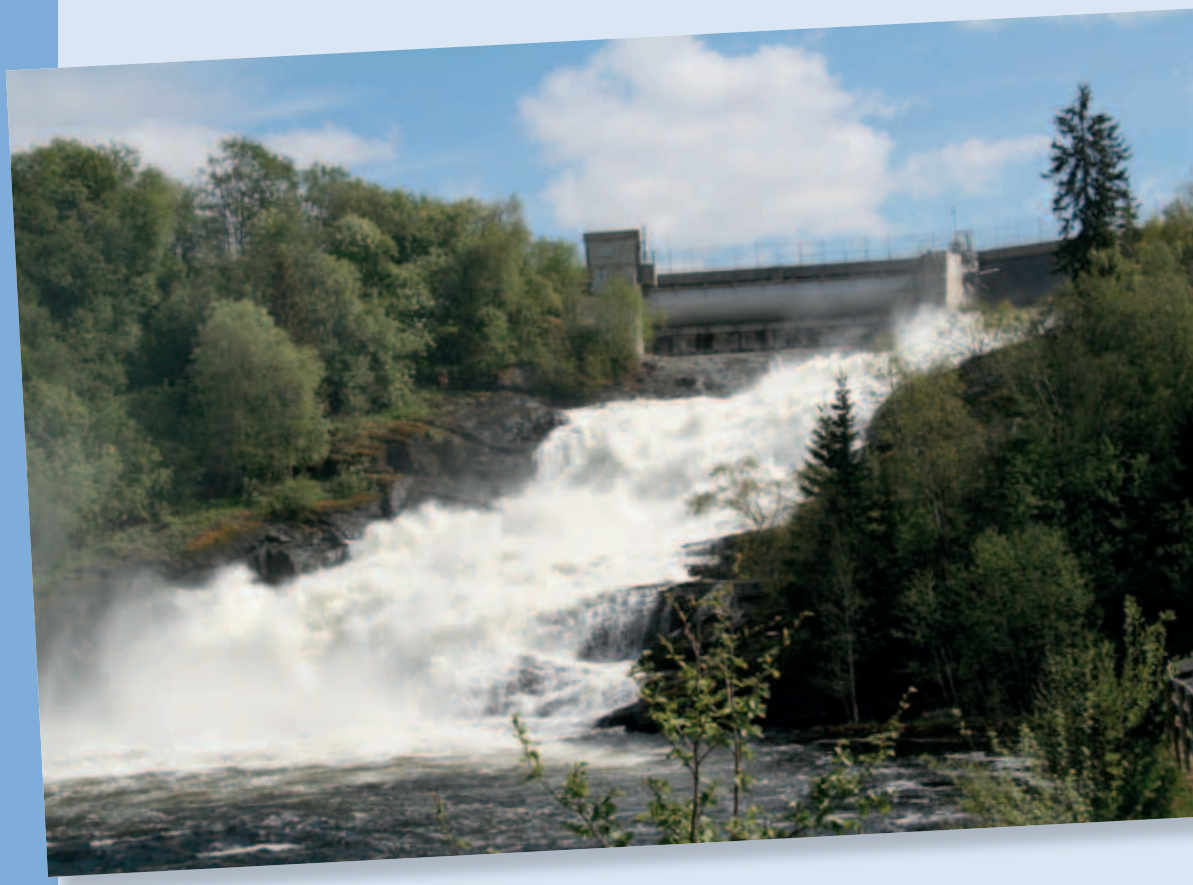
Annual Report 2011

STRATEGIC AREA

Energy and Petroleum – Resources and Environment



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 gave priority in 2000 to six strategic areas where multi-disciplinary teamwork provides 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**

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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 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.

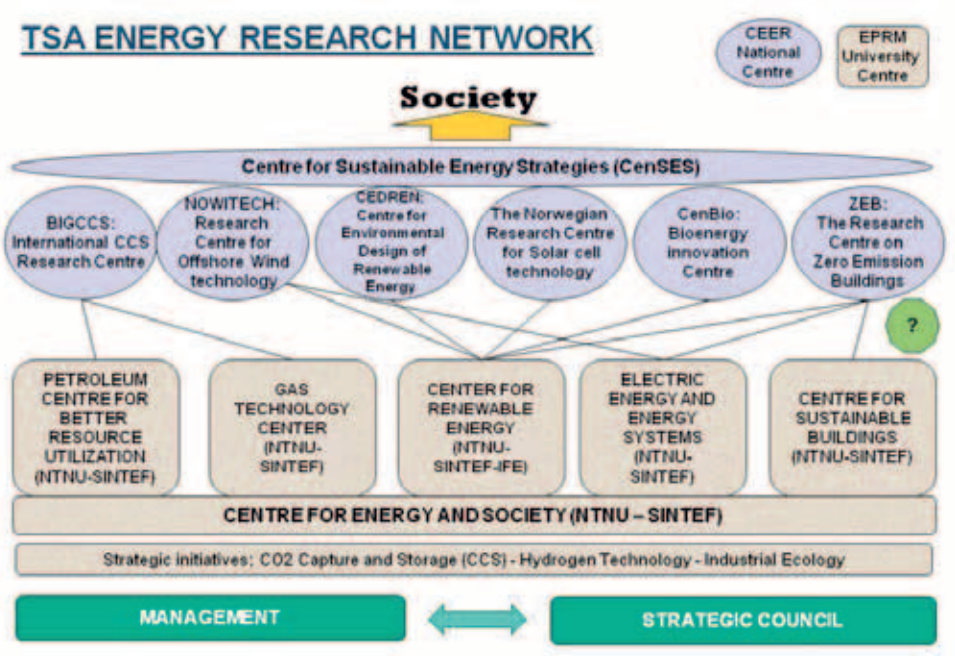
Energy is essential to society because we need it to provide for fundamental human needs, such as food, clothing, housing/shelter, transportation, health and recreation – in short, everything that is needed to live a good life on this planet.

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 knowledge and innovations essential to the global transformation process that will be essential 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 and 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.



Schematic sketch of TSA Energy's network

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

Thanks to 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 value, because 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 society.

- Six goal-oriented multidisciplinary research centres
  1. Centre for Energy and Society (NTNU)
  2. Centre for Sustainable Buildings (NTNU-SINTEF
  3. Centre for Renewable Energy (NTNU-SINTEF-IFE-UiO)
  4. Gas Technology Centre (NTNU-SINTEF)
  5. Petroleum Centre for Better Resource Utilization (NTNU-SINTEF)
  6. Centre for Electric Energy and Energy Systems (NTNU-SINTEF)

- In addition, we have developed strategic initiatives that involve cross-disciplinary work between the centres:
  1. CO_2 Capture and Storage (CCS)
  2. Hydrogen Technology
  3. Industrial Ecology

Our research teams are involved in the following national Centres of Excellence:

- Four Centres for Research Based Innovation (CRI):
  1. Integrated Operations
  2. Multiphase Flow Assurance
  3. Innovative Natural Gas Processes and Products
  4. Drilling and Well Technology for Improved Recovery

- Seven Centres for Environment-Friendly Energy Research (FME), which were started in 2009-2011:
  1. Centre for Sustainable Energy Strategies (CenSES)

2. BIGCCS – International CCS Research Centre
3. Centre for Environmental Design of Renewable Energy (CEDREN)
4. Bioenergy Innovation Centre (CenBio)
5. Norwegian Research Centre for Offshore Wind Technology (NOWITECH)
6. The Norwegian Research Centre for Solar Cell Technology
7. The Research Centre for Zero Emission Buildings (ZEB)

These FMEs constitute a total research investment of more than NOK 2.5 billion 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 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:

1. 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 our industrial and societal development.
2. 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.
3. Now the aim is to invent new approaches to climate friendly energy, based on renewable energy, CCS and energy efficiency.

The Energy Strategic Area (hereafter 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, all of whom work in state-of-the-art laboratories. These research groups have been created by the faculties together with industry, 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 the "Energy team". The Faculty-Centre-Matrix below shows how we have developed cooperative networks with almost all NTNU's faculties.

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
Humanities	X		X			X

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 from 2011–2015:

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

Our priorities are based upon Norway's proximity to the North Sea and the Arctic Basin, which contain 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 (see IEA Energy Technology Perspectives 2010), as well as Norway's Energy 21 national 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 used by society.
- Strengthen our activity in smart grids (also called "Networks of the Future") in cooperation with the ICT (Information and Communication Technology) Strategic Area.
- Use 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 continuation of our 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

Energy21

The second phase of the work on the new national energy strategy "Energy21" was completed in 2011. Energy21 was established by the Ministry of Petroleum and Energy in 2007 with the goal to develop and implement a national strategy for research and development in the energy sector. The first strategy was delivered in February 2008 with the vision document "Norway: "Europe's energy and environment nation – from national balance to green delivery". This resulted in a strong growth in the energy research budgets from the Research Council of Norway, and in the establishment of the FMEs. Since then, Energy21 has been working on a new more comprehensive goal-oriented strategy with respect to research. More than 140 people from the industry, research institutions and universities have been involved in creating more specific plans within 14 thematic areas.

Based on this material, the Energy21 board carried out a strategic process, where emphasis was put on three main goals

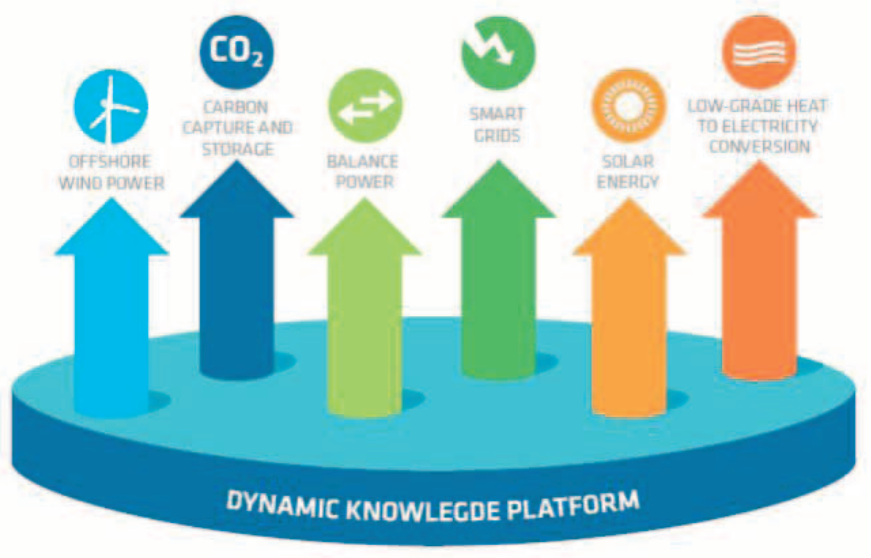
1. Increase value creation based on national energy resources and energy utilization
2. Shift in energy sources, by the development of new technology, and efficient production of environment-friendly energy
3. Develop internationally competitive industry and competence for the energy sector

Based on these goals, Energy21 decided that the following areas should be given priority in the coming period:

- Solar Power – strengthen industrial development
- Offshore Wind – Industrial development and resource utilization
- Improved utilization of resources by balance power
- Value creation and value safeguarding through Carbon Capture Transport and Storage (CCS)
- Flexible energy systems – smart grids
- Energy utilization (efficiency) – Converting low temperature heat to electricity

These areas coincide well with NTNU's key technology areas in the energy sector.

Researchers from the "Energy Team" at NTNU and SINTEF participated actively in this process, and NTNU and SINTEF have also been represented on the Energy21 Board. A new Energy 21 Board will be appointed in 2012 to follow up on the implementation of the strategy



The six priority areas emphasized in Energy21

Main events in 2011

- The Preparatory Phase Project for the Pan-European Laboratory ECCSEL initiative was started and is being led by NTNU, with a budget of NOK 15 million for the first two years.
- NTNU has joined and contributed to the establishment of the European Partnership for Sustainable Energy Education, Innovation and Technology (SEEIT), in cooperation with DTU, TU Delft, TU Munich, ALU Freiburg, Aalto University, Politecnico Torino, SINTEF, ENEA, and Fraunhofer ISE. SEEIT works on bioenergy, wind energy, solar energy, energy efficiency and energy systems, and a SEEIT network has been developed at NTNU.
- The European Commission's SET plan for Education and Training Initiative includes expert groups in 13 technology areas. NTNU has recruited members for seven of these areas and will act as the reporter for two, CCS and Electricity Grids
- 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 successfully employed by the Research Council, NTNU and SINTEF as target areas for developing strategic international cooperation on "Environment friendly energy".
- An NTNU-SINTEF document for the Ministry of Petroleum and Energy's Energy Commission about the most important challenges for the Norwegian energy supply until 2050, and how to meet these challenges was written and presented to the commission on September 22.
- Two major seminars / workshops by the "Joint Research Centre (JRC) for Sustainable Energy" between Shanghai Jiao Tong University (SJTU) and NTNU have been held in Shanghai (3-5 May) and Trondheim (19-21 September). A third workshop on education was arranged in Shanghai on 29-30 November.
- In 2010, 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 Cabin" (ZE+H). Twenty finalists have been selected to exhibit their entries in Madrid in 2012. In 2011, the students' proposed building project, the solar zero energy house "ZE + Hytte" (Zero Emission Cabin) was further developed with assistance from CSB.
- NTNU established membership in E2BA, Energy-Efficiency in Buildings Association, which is a subgroup under ECTP, European Construction Technology Platform in 2011. NTNU has taken the position of National Liaison Point in E2BA.
- IEEE PowerTech was held in Trondheim in June 2011. About 350 persons participated.
- The International Conference on Dielectric Liquids was held in Trondheim in June 2011.
- SFFE and Technoport decided to join forces and collaborate on organizing an international conference on climate and environment-friendly energy in the spring of 2012. The 2nd Renewable Energy Research Conference (RERC) was thus organized as part of Technoport 2012 - Sharing Possibilities.
- In August NTNU, UiO, University of Bergen (UiB), University of Tromsø (UiT), the Norwegian University of Life Sciences (UMB), SINTEF and IFE entered into an agreement to establish a Norwegian research school on renewable energy. The project is being managed by SFFE and will run for 2.5 years.
- The 2nd Trondheim Gas Technology Conference (TGTC-2011) was organized by GTS on November 2-3 with 69 participants form R&D institutions, universities and industry. There were 30 oral presentations and a poster session.
- In April 2011, BRU hosted the 7th international conference on Rock Physics and Seismic (ROSE11) with approximately 75 participants. The conference was followed by a two-day short course in seismic imaging.
- BRU's Centre for Integrated Operations hosted the 8th international conference in the area of Smart Fields/ Integrated Operations. NTNU Rector Torbjørn Digernes opened the conference and the Minister of Oil and Energy, Ola Borten Moe, gave the dinner speech. The conference attracted 275 participants and took place on 15-16 September.
- Professor Martin Landrø was awarded the ENI Prize for 2011. The prize is frequently called the Nobel Prize of Energy. Professor Curtis H. Whitson received the Anthony F. Lucas Gold Medal from the Society of Petroleum Engineers (SPE) at SPE's Annual Technical Conference and Exhibition.
- In the aftermath of the establishment of CenSES in February 2011, the centre was officially launched by the Oil and Energy Minister on the Dragvoll campus in June. Around 50 delegates from industry, research and public sector participated in the event.
- Professor Edgar Hertwich and Professor Daniel Müller from the Industrial Ecology Programme are both main authors in IPCCs 5th assessment report. Hertwich made a contribution to the chapter on energy systems as well as coordinating the work on life cycle assessments for the entire report. Müller is the main author on the chapter on human settlements and infrastructure.

Energy Campus North

The Arctic may be an important energy region in the future, but only if we explore and develop its valuable energy sources (oil, gas and renewable energy) 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 by making our skills and expertise available for the development of all the new approaches needed to achieve the initiative's ambitious goals. New LNG technology and multiphase flow technology from NTNU and SINTEF made it possible for Statoil to develop the Snøhvit (Snow White) field. This was only the beginning.

One decisive area is education and expertise. 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, which is regarded as the "Energy city" of northern Norway, with of all the energy installations and companies that are present and active there.

In its first years, ECN worked on building cooperation between the partners to develop new energy education offers. After the restructuring of ECN in 2011, our new focus will now be to offer and make existing energy expertise and education at NTNU available to the industry in Finnmark. NTNU will use ECN resources to create an active NTNU education centre with the potential to:

- Conduct attractive courses for our own energy students at the region's unique energy installations (LNG plant at Melkøya)
- Conduct additional education courses from NTNU on topics relevant to the industry ("project management" and "arctic environmental maintenance").
- Develop strategic networks between the industry and NTNU professors on selected areas to develop master's theses on topics relevant to the industry in Hammerfest. Areas of relevance may be gas technology, renewable energy, electric grids, etc.
- Support and assist projects developed by ECN's industrial partners.

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 energy expertise available to innovative programmes in other parts of the country. The initiative is being handled by TSA Energy.

Centre for Sustainable Buildings (CSB)

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

- Research and development
- Education
- International and outreach activities

A multidisciplinary approach is the main target for all CSB activities.

A major turning point for this centre was in 2009, with the establishment of a national Centre for Environment-friendly Energy Research (FME), Zero Emission Buildings (ZEB). This centre will be operational for 8 years (2009 – 2017), and addresses many of the activities planned for R&D in CSB. There are, however, NTNU and SINTEF groups that are collaborating with CSB but that are not participating in ZEB.

Main results 2011

Multidisciplinary centre research collaboration
In 2011, two new R&D centres were established at NTNU/SINTEF that are both of interest for collaboration with CSB. The Centre for Sustainable Energy Studies, CenSES, is a FME established to develop knowledge and for decision support to promote the introduction of a new sustainable energy system. CenSES will integrate insights from economics, the social sciences, sociology, and studies of innovation, technology and science.

The new Norwegian Smart Grid Centre has grown out of a collaboration between R&D institutions and relevant industry, and was established to develop future electrical energy systems that use ICT technology. The centre is working to gain FME status. CSB will start planning future cooperation activities with both of these new centres after they are more fully established.

The ZEB centre has added more PhD and postdoc candidates in 2011, totalling 18 at the end of 2011, representing more than 15 full years of research activity. Four of these are financed through TSA Energy, the rest through ZEB financing.

Educational activities

The Faculty of Architecture and Fine Art started a new international master's programme in Sustainable Architecture in 2010. Students and faculty from the programme, along with ZEB researchers, participated in the international competition Solar Decathlon Europe 2012, and were successfully awarded a place among the 20 groups that were promoted to the final round. In 2011, their proposed building project, the solar zero energy house "ZE + Hytte" (Zero Energy Cabin) was further developed, also with some assistance from CSB. In 2012, two prototypes will be built, with one to be erected in Madrid for the exposition in September. The other will be built on the NTNU Campus to serve as a "living lab" for the ZEB Centre.

International and outreach activities

In 2010, a Joint Research Centre was established between Shanghai Jiao Tong University and NTNU, with "Energy Use in Buildings" selected as one of the main areas for joint research. A fundamental research project has been selected and will be carried out by two coordinated PhD candidates, financed jointly by SJTU and NTNU. The project will start in 2012.

Through CSB and ZEB we have again been active in the EU's 7th RDD Framework applications. This also includes project proposals for IEE, Intelligent Energy Europe. Participants in ZEB have also worked in the establishment of new European Energy Research Arena (EERA) group on "Smart Cities". NTNU also established membership in 2011 in E2BA, the Energy-Efficiency in Buildings Association, which is a subgroup under ECTP, the European Construction Technology Platform. NTNU has taken the position of National Liaison Point in E2BA, which will ensure direct contact with the planning of EU research calls. The Research Council of Norway has awarded funding for these strategic activities.

Participants in CSB have also been active in the establishment in 2011 of a regional affiliate of IBPSA, the International Building Performance Simulation Association. IBPSA Nordic has four member countries: Denmark, Finland, Norway and Sweden. IBPSA Nordic was founded to promote the science and practice of building performance simulation and to improve the energy, environmental and economic performance of buildings and their systems. CSB has assisted with some funding, and NTNU participants are active in the management of the new organization.

In February 2011, NTNU's rector and a group of energy experts visited several R&D institutions in India in order to meet with leadership and discuss possibilities for strategic cooperation in the energy field. Then, in October, NTNU staged an Indian week in Trondheim which included a seminar on "Green Buildings". Selected Indian partners were invited to participate, with the goal to identify areas where cooperative projects could be developed. The main Indian institutions for this collaboration are The Energy and Research Institute in New Delhi (TERI) and Shri AMM Murugappa Chettiar Research Centre (MCRC). The contacts established will be further strengthened in 2012 with a workshop for planning specific projects for future joint energy research in this field.

A large team of ZEB and CSB personnel participated in the Transatlantic Science Week 2011 in Los Angeles in October, to celebrate their long-term partnership with Lawrence Livermore National Laboratory at the University of California, Berkeley. This scientific contact is now also formalized in ZEB by appointment of a LBNL expert to the International Advisory Committee.

A happy ending for the "Green Buildings" seminar

Centre for Electric Energy and Energy Systems

The research centre plays an active role in developing technology for the production, transportation and use of electric energy. The Gemini Centre combines 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 reliability of power supplies

Transport of electricity

- Materials and components for HVDC
- Condition monitoring, maintenance and refurbishment
- 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

Education

The centre is involved in several programmes. The *Energy and the Environment Study programme* (5 years) 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 as well as the admission requirements have been high for several years. A total of 155 students are now enrolled each year, and the number of female students is stable at around 40%. The *Electric Power Engineering* programme (2 years) is an international programme that has been operational for several years while the *Energy Use and Energy Planning* programme started in 2010.

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.

A national smart grid centre is under construction with participation from universities, research institutions and broad industry involvement. This is an interdisciplinary activity where departments from 6 of NTNU 7 faculties are involved.

The centre is a participant in several EU-funded projects where either NTNU or SINTEF is the main Norwegian partner.

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.

Main results 2011

Education

- The evaluation and reconstruction of the Future Energy and the Environment Study Programme (FREMS) was completed in 2011 and the new programme will start in the autumn of 2012.
- A new Erasmus Mundus programme was funded on wind energy in partnership with DTU, Denmark; TU Delft, the Netherlands; and the University of Oldenburg, Germany. The programme will start in 2012 and is a direct result of the cooperation within SEEIT.

Research

- NOWITECH: An increasing number of PhD students at the centre and active participation in the 8th Deep Sea Offshore Wind R&D Seminar (January 2011).
- Smart Grid Centre:
  - Formal centre with 6 research partners and 37 members from industry.
  - Demonstration projects established (centre involved in development).
  - Five PhD students and postdocs recruited.
- EERA Smart Grid project awarded as a joint activity with DTU (Denmark) and ETH (Switzerland).
- Nordic Energy Research project STRONgrid awarded.
- Our close cooperation with SINTEF Energy Research is carried out through the continuation of a GEMINI centre. The renomination of the centre was approved in 2011. Under this Gemini umbrella, five BIP and one KMB were approved and funded by the Norwegian Research Council in 2011.

Capacity building
- Two professors whose expertise is in smart grids were recruited. One of the professorships is sponsored by Hafslund ASA.
- Laboratory staff (MSc / PhD) sponsored by NTE Nett.
- Assistant professor sponsored by NTE Nett.

Infrastructure
- Investment in a new High Current Breaker Laboratory (Total NOK 5 mill).
- Upgrade and further development of SMARTGRID laboratory on the NTNU premises.

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, CIGRE, IEA, IEC).
- IEEE PowerTech was held in Trondheim in June 2011, with about 350 participants.
- International conference on Dielectric Liquids was held in Trondheim in June 2011.
- Participation in Joint Research Centre with Shanghai Jiao Tong University.

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 within the field of 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 utilization of renewable energy sources and technologies.

The Centre for Renewable Energy (SFFE) was established in 2004 as a cooperative unit between the Norwegian University of Science and Technology (NTNU) and SINTEF. In December 2005 the Institute for Energy Technology (IFE) became an equal partner and in January 2011 the University of Oslo (UiO) joined the centre.

At NTNU, the Centre is placed under the Energy and Petroleum - Resources and Environment strategic area. At SINTEF and IFE, the Centre is incorporated in the management and at UiO it is affiliated with the Faculty of Mathematics and Natural Sciences. The internal network of NTNU, SINTEF, IFE and UiO comprised more than 250 scientific researchers and 200 PhD students in the field of renewable energy in 2011.

The strategy of the Centre for Renewable Energy is:
- **Influence:** The Centre participates in the public debate on renewable energy research and innovation and the framework conditions in Norway.
- **Networking and coordination:** The Centre is a platform for national and international cooperation, and coordinates the renewable energy expertise at the member institutions NTNU, SINTEF, IFE and UiO.
- **Dissemination and information:** The Centre is an information resource on renewable energy research in Norway, and works to increase the common knowledge on the subject.
- **Recruitment:** The Centre works to strengthen the educational facilities on renewable energy in Norway, and to recruit young people to renewable energy research and industry.

Main results 2011

- SFFE's partnership with the University of Oslo (UiO) was expanded as the Faculty of Mathematics and Natural Sciences at UiO became a partner in the Centre.
- SFFE and the Norwegian Climate Foundation in Bergen carried out a consensus process to discuss the framework necessary for establishing an offshore wind industry in Norway. The project involved several actors from research institutions and industry in Norway and resulted in the report "Et hav av muligheter" ("An ocean of possibilities"). In preparing the report, support was gathered from a number of prominent players in Norwegian research, trade unions, industry and environmental movements to tell political authorities that Norway should invest more strongly on offshore wind power. The report was published in January 2012.
- In October 2011, SFFE organized a "Climate Day" in Trondheim, where the aim was to give an update on the latest news from climate research in Norway. The majority of the participants came from NTNU and SINTEF, but the County Governor's o ffice, the County Authority, local businesses and the Directorate for Nature Management were also represented in the audience. Eight speakers

from different research institutions in Norway gave excellent and educating lectures on topics related to climate research.

- SFFE and Technoport decided to join forces and collaborate on organizing an international conference on climate and environment-friendly energy in the spring of 2012. The 2nd Renewable Energy Research Conference (RERC) was thus organized as part of Technoport 2012 - Sharing Possibilities.
- In August 2011, NTNU, UiO, University of Bergen (UiB), University of Tromsø (UiT), the Norwegian University of Life Sciences (UMB), SINTEF and IFE entered into an agreement to establish a Norwegian research school in renewable energy. The project is managed by SFFE and will run for 2.5 years.
- SFFE organized 17 public lunch lectures on topics related to renewable and environment-friendly energy during 2011. Most of the lectures attracted an audience of 30-50 people. This year's most popular lunch lecture was Professor Ånund Killingtveit's presentation of the IPCC special report on renewable energy, with more than 80 attendees.

SFFE leader and main responsible Gabriella tranell wishes welcome to the "Climate day"

Gas Technology Centre

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

1. Increase the visibility of gas technology R&D at NTNU/SINTEF.
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 coordination and synergies in gas technology R&D at NTNU/SINTEF.

Main results 2011

2nd Trondheim Gas Technology Conference (TGTC-2011), November 2–3.
TGTC-2011 (www.sintef.no/tgtc2011) was organized by GTS on with 69 participants from R&D institutions, universities and industry. There were 30 oral presentations and a poster session. Among the keynote speakers were Rob Klein Nagelvoort, CEO and Principal Adviser at LNG Tech Consult from the Netherlands, Sigurd Gaard, Technology Manager for Genesis Oil & Gas, and Professor Anders Holmen from NTNU.

Gas Technology Activities 2010-2011 report
The GTS produced a report entitled Gas Technology Activities 2010-2011 to promote the large NTNU/SINTEF gas community. The report provides an overview of ongoing gas technology activities at NTNU and SINTEF and has been distributed nationally, at TGTC-2011, as well as within NTNU and SINTEF.

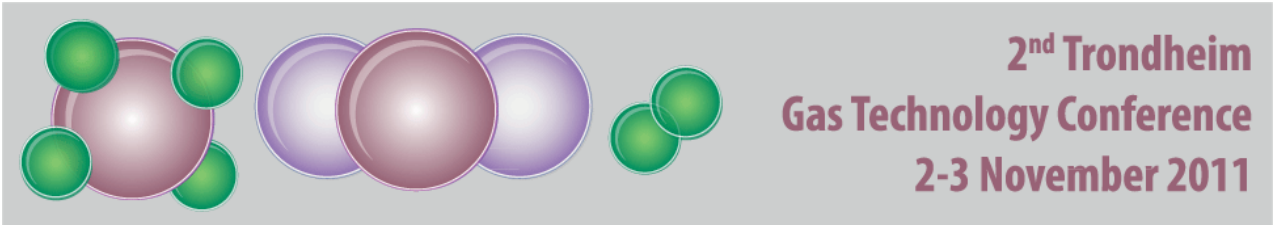
Student excursion and LNG course at Statoil Melkøya on October 17–21
The GTS and Statoil organized a student excursion to Ham-

merfest and Statoil's Melkøya facility there. Twelve students were selected out of 70 applicants from different NTNU MSc programmes. The students demonstrated both skills and enthusiasm during the 5-day course in LNG technology.

Internationalization activities
Visits and participation in delegations and conferences to Brazil, Japan, China and the Netherlands were made to promote existing and new partnerships in natural gas processing, hydrogen and carbon capture and storage.

The GTS also participates and contributes to the activity in the Joint Research Centre with Shanghai Jiao Tong University (SJTU), where gas technology (LNG heat exchangers) is one of the selected fundamental research projects.

Further details are available in the GTS Annual Report 2011 at www.ntnu.no/gass.



Centre for Better Resource Utilization of Petroleum (BRU)

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 that development has been visits to and discussions with around 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 15 September 2005. The report may be downloaded from http://www.petroleum.ntnu.no/~kleppe/BRUreport.pdf. The strategic plan identified 4 key areas for research in the years to come:

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

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

Major research programs (incl. partnerships)
- ROSE - the rock seismic programme
- 4D seismic - reservoir simulation programme
- Improved oil recovery programme
- Subsea programme
- New drilling methods programme
- Unconventional oil recovery programme
- SFI-Smart Fields/Integrated Operations programme
- FME-Subsurface storage of CO_2
- SFI-Centre for Drilling and Wells for Improved Recovery (new)

Main results 2011

International academic collaboration
NTNU has a wide range of international partners in the petroleum area. The current key countries are Angola, Bangladesh, Brazil, Canada, France, Italy, Mozambique, the Netherlands, Nigeria, Russia, Spain, Tanzania, Ukraine and the USA. Close to 50% of the MSc students and 80% of the PhD candidates in exploration and production are non-Norwegian. Some of the collaborating institutions in 2011 were: Agostinho Neto Universidade (Angola), BUET (Bangladesh), Carnegie Mellon University (USA), EMU (Mozambique), Stanford University (USA), TU Delft (the Netherlands), Pontifícia Universidade Católica do Rio de Janeiro (Brazil), CAMPINAS (Brazil), University of Oklahoma (USA), University of Central Florida (USA) and Mines Paris Tech (France). A new univer-sity partner in Brazil in 2011 is Universidade Federal da Santa Catarina.

International Conferences arranged in Trondheim

- **The Rock Seismic Conference – ROSE11**
  During April 2011, the 7th International Conference on Rock Physics and Seismic was arranged at NTNU. The conference included sessions on rock physics, time lapse and reservoir characterization, and imaging and inversion. Around 75 people participated in the conference. The conference was followed by a two-day short course in seismic imaging, conducted by Paul Sava and Ian Jones.
- **The Integrated Operations Conference – IO11**
  On 15-16 September, the 8th International Conference on Smart Fields/Integrated Operations was arranged by the Centre for Integrated Operations (SFI) in Trondheim. The theme of the conference was Science and Practice, and presentations were held by academia and industry from all over the world. Around 275 people participated. NTNU Rector Torbjørn Digernes opened the conference, and the Norwegian Minister of Oil and Energy, Ola Borten Moe, gave the dinner speech. The conference is organized annually, and the next conference will be in September 2012.
- **The SPE Applied Technology Conference on the Norne Field**
  On 15-16 June 2010, NTNU, Stanford University, TU Delft, Statoil and the Society of Petroleum Engineers (SPE) arranged an international workshop in Trondheim on benchmarking of reservoir simulation models using real field data from the Norne Field. Around 80 people from all over the world participated.

International educational programmes

The Petroleum Department has established several programmes for support of petroleum education in oil producing developing countries. The current programmes include Bangladesh, Mozambique, Angola, Nigeria, Venezuela and Tanzania. In 2011 Tanzania was added as partner.

Graduates

In 2011, 80 MSc candidates graduated in the disciplines of Petroleum Engineering and Petroleum Geoscience. Thirty-five of the graduates were non-Norwegian. Among the Norwegian students, around one-third take a one-year exchange period at a foreign university, primary in the US, Canada, Brazil and Australia. A total of 9 PhD candidates defended their research in 2011.

Publications

A total of 135 titles, including refereed journal publications, conference presentations, posters, etc. were reported, of which 62 were in refereed journals or digital proceedings as extended abstracts or full papers. In the system of the Norwegian publication points, a total of 55 points were registered in 2011, as compared to 50 in 2010 and 44 in 2009.

SFI Integrated Operations

- Phase I of the SFI is completed and plans for Phase II approved
  The Research Council of Norway has conducted their mid-term evaluation of the SFIs. The Centre for Integrated Operations passed the evaluation without any critical remarks. Following the evaluation, the IO Centre presented a research plan for Phase II 2012-2014, and invited all existing partners to continue their membership. The Board of the Centre approved the plans, and all current industry members have accepted the invitation to continue in their memberships. The Research Council, SINTEF and IFE are continuing as partners, with NTNU as the host institution.
- BP becomes new industrial member in the Integrated Operations SFI
  An important enhancement of industrial relations took place when the international major oil company BP decided to become an industry member of the SFI Integrated Operations in 2011. With BP, the total number of industrial partners for Phase II is 14.

Partner in a new SFI

The four key research actors for 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 an SFI in December 2010. Planning and research activities started in 2011, and the first board meeting was held in June.

Industrial collaboration

Close collaboration with industry insures relevance of education and research and provides financial support for new facilities and research. Key industrial partners during 2011 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, Saudi Aramco, Schlumberger, Shell, Spring Energy, Statoil, TOTAL, Wavefield Inseis, Wintershall, and VNG. New agreements in 2011 included BP as a partner in the IO Centre, and Saudi Aramco as a partner in ROSE.

International research prizes

Professor Martin Landrø was awarded the ENI Prize for 2011. The prize is frequently called the Nobel Prize of Energy. The prize was awarded by the Italian President Giorgio Napolitano during a ceremony in the Salone delle Feste Del

Quirinale in June. Professor Curtis H. Whitson received the Anthony F. Lucas Gold Medal from the Society of Petroleum Engineers (SPE) at SPE's Annual Technical Conference and Exhibition. For the second year in a row the IO Centre received IBM's Open Collaborative Research Award. Professor II John-Morten Godhavn received the Best Application Paper Award at the IFAC World Congress in Milan in September, and PhD candidate Alexander Juell was awarded SPEs "Best Reservoir Engineering Paper" for Young Professionals in November.

Professor Martin Landrø receives the ENI Prize for 2011 from the Italian President Giorgio Napolitano during a ceremony in the Salone delle Feste del Quirinale

Centre for Energy and Society

The research areas covered by the centre include:
- Energy policy and the politics of new renewable energy
- Energy and everyday life
- 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

The strategic goals for 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 our dissemination and publication activities and enhancing our understanding of knowledge needs, and to recruit and develop further (educate) excellent students.

The following people were engaged in the centre's activities in 2011:
- Three professors and three associate professors
- Three research scientists
- Three postdocs
- 20 PhD students
- Two guest researchers (ZEB)
- Coordinator (CenSES)

Main results 2011

In 2011, the following projects were funded:
- Synthesis report project. The energy research at Centre for Energy and Society. (RENERGI)
- Era-net: Integrating households in the smart grid (IHS-MAG)
- The development of offshore wind technology and industry in – and between – China and Norway
- Convincing the sceptics, mobilizing the supporters, supporting the planners. Organizing extensive and robust user support for the Brøset development (Husbanken)
- Infrastructure: lab (RENERGI)

The research group continued to grow a little in 2011 as two new PhD candidates were engaged. Two guest researchers also visited the centre. We would like to highlight that in 2011 the Centre got funding for the first Shanghai Jiao Tong – NTNU Joint Research Centre PhDs. This project will focus on the development of offshore wind technology and industry in – and between – China and Norway and takes on a multi-level approach to study technological learning and innovation in the Chinese and Norwegian wind turbine industry. The project will be approached both from a systemic perspective where one aim is to map out industries, policies and markets that are participating in the development of offshore wind technology and industry in China and Norway. The focus is on a) What actors are involved, drivers, challenges and the role and presence of MNCs, and domestic private entrepreneurs and investors b) The integration between research-driven and experience-driven modes of

learning and c) The role of economists, engineers and other actors in decision-making processes regarding energy systems and technological learning. The other angle to study technological learning and innovation in the Chinese wind turbine industry involves a case study to analyse the role of international entrants and the interaction between internationals and locals. This angle will look into a specific Norwegian company's entry and activities in China and map drivers and barriers on both sides, the dual learning process and the making of technology and internationalization, opportunities for mutually beneficial industrial cooperation, and means of facilitating such cooperation.

In the aftermath of the establishment of CenSES in February 2011, the centre was officially launched by the Minister of Petroleum and Energy Ola Borten Moe on the Dragvoll campus in June. Around 50 delegates from industry, research and the public sector participated in the venue. The Centre continued to be engaged in the Norwegian Smart Grid Centre and was represented in both the interim board of the Centre as well as in the core team of the Centre. The Centre also received funding from ERA-net to start a new project on smart grids with colleagues from Aalborg University, the Danish Building Research Institute, ChooseEV, Sydenergi as well as Technalia Research and Development and ZIV Metering Solutions in Spain. NTE and Enova are Norwegian partners. The goal of the project is to contribute with new knowledge on how to develop a comprehensive design for household smart grid solutions that integrate the specific characteristics of the three domains that intersect at the household level: 1) technologies in households, 2) electricity consuming everyday practices of household members and 3) the electrical system and the administrative and institutional rules that affect the implementation of new smart grid solutions (e.g. standards for home automation and economic incentives). These three domains are mutually intertwined and decisive for the design and success of household smart grid solutions, and by synthesizing results from the study of each of these domains, this study contributes to the development of functional and effective solutions.

The Centre for Energy and Society is also one of nine partners in NORD-STAR, a Nordic Centre of Excellence for Strategic Adaptation Research, which was launched in May 2011. Within the scope of climate impacts and climate policy, NORD-STAR focuses on two issues, land-use change and energy transitions. NORD-STAR researchers analyse and communicate needs and opportunities for strategic adaptation using two methodological approaches; scientific visualization and modelling, and policy analysis. Combining the two issues and the two methodological approaches, NORD-STAR has four main projects, of which the Centre for Energy and Society has the joint leadership for one on Energy transition management.

In 2011 the Centre for Energy and Society continued to lead one of the five work packages of 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) their implementation. Important in this regard is the participation of several of our researchers in the trans-disciplinary project Towards carbon neutral settlements – processes, concept development and implementation, where the practical aim is to develop Brøset into a good neighbourhood where the inhabitants' CO_2 emissions are reduced drastically through planning as well as through technical and social solutions. We also co-hosted thematic sessions at the 4S annual meeting in Cleveland on Transition Strategies.

Altogether we arranged or co-hosted several sessions, seminars and workshops during 2011, the most important of which were:

- CenSES 2nd Innovation Forum for FMEs, Trondheim, December
- CenSES annual conference, Oslo, December
- Two CenSES PhD seminars in Oslo and Selbu
- Workshop, Joint Research Centre, Jiao Tong University, Trondheim, September
- Workshop: "Making zero emission buildings normality", Trondheim, 30 May 2011
- Workshop: "User evaluations of energy efficient buildings. The interplay of buildings and users in seven European case studies", Oslo, 27 October 2011

This has also been an active year regarding dissemination, with 7 articles in journals and edited collections, 37 scientific conference papers in addition to 45 other dissemination activities. We produced four CenSES newsletters and a CenSES blog was established. The Centre is also involved in a blog on **http://www.forskning.no/** called "Vitenskaperne".

Industrial Ecology Programme

The Industrial Ecology Programme (IndEcol) is a multi-disciplinary university programme. The research focuses on understanding how society uses resources and causes pollution in the process of producing infrastructure, goods and services, and on the governance of these processes with the aim to reduce pollution and allow for sustainable resource use. One of these areas is environmental assessment of energy technologies. Climate change is one of the fundamental challenges facing our society today. The adoption of energy efficient technologies and the shift to clean energy sources are indispensable for stabilizing greenhouse gas concentrations in the atmosphere, even though they are probably not sufficient. Substantial investments in new technologies are required, and we have to make sure that these investments are directed to the right technologies and that the generation of new problems is avoided. IndEcol staff participates in IEA task forces, the IPCC and the UNEP Resource Panel.

Main results 2011

The main achievements in the area on energy is the defence of three PhD theses, improvement of models for assessing the climate impact of changes in forest management, as well as important contributions to the IPCC 5th assessment report.

Agent-based modelling and simulation of clean heating system adoption in Norway

In her thesis, Bertha Maya Sopha seeks a better understanding of consumers' decision-making on heating systems and to assess the potential application of Agent-Based Modelling (ABM) in exploring adoption mechanisms. Heating system selection by Norwegian homeowners was used as a case study. Some major findings in the thesis are:

- In addition to socio-demographic factors, both information and functional reliability are important features in a homeowner's choice of a heating system.
- An integrated psychological model shows that the decision to adopt wood-pellet heating is a deliberative decision.
- Based on scenario simulations it is suggested that a higher adoption of wood-pellet heating could be achieved by informing homeowners about the relative advantages of wood-pellet heating and improving wood-pellet heating technology, whereas focusing norms/values is not a promising intervention.

Environmental evaluation of carbon capture and storage technology and large scale deployment scenarios

CCS is an energy intensive process and demands additional chemicals and infrastructure. The capture processes may also have certain direct emissions to air (NH3, aldehydes, solvent vapour, etc.) and generate solid wastes from degradation by-products. Bhawna Singh explored these potential trade-offs in environmental impacts in her thesis in order to better understand the impact of these in a potential large-scale application of CCS. Some major findings in the thesis are:

- With different technologies, reductions in the greenhouse gas emissions are in the range of 74-78% for coal systems and 64-73% for natural gas systems.
- For natural-gas-based power plants with CCS, fuel production becomes the most important emissions source of greenhouse gases, while for coal, combustion remains key.
- There is a net increase in other environmental impact categories except a reduction (7-15%) in acidification and particulate formation. The human toxicity impact increases by 40-75%, terrestrial ecotoxicity by 60-120%, and eutrophication by 60-200%.
- The results for environmental evolution of CCS systems show that the future techno-economic developments will enable a significant reduction of about 30% for coal and 20% for natural gas fuel by 2050 across all impact categories.

Climate impact of changes in forest management

The climate impact of different forest management regimes has long been ignored in environmental assessments of bioenergy due to its (long-term) carbon neutrality. However, carbon neutrality is shown to not automatically result in climate neutrality. Based on contributions from the PhD of Ryan M. Bright and research funded by the FME CenBio, new methods for assessing the impacts from forest management have been developed. Some major findings are:

- Climate impact from biomass systems can be assessed based on knowledge on rotation periods and time horizons. For a system with long rotation periods (e.g., boreal forests) and time horizons of around 100 years, changes in forest outtake will make a clear contribution to climate change.
- Albedo impacts are found to be too significant to ignore in formulation of future climate and forest management policies in Norway.

- Albedo effects of aff-/re-/deforestation can counteract and even overcompensate the CO2 drawdown in boreal latitudes.

Contributions to the IPCCs 5th assessment report
Professor Edgar Hertwich and Professor Daniel Müller are both main authors in IPCCs 5th assessment report. Hertwich's contribution is in the chapter on energy systems as well as in coordinating the work on life cycle assessments in the entire report. Müller is main author on the chapter on human settlements and infrastructure.

The climate impact from forestry management is highly depending on the rotation periods of the forest as well as changes in albedo.

International Cooperation

All of the strategic area's centres 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 expand its industrial cooperation, particularly the European Union, Asia (Japan, China and 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.

The strategic area enjoys an excellent collaborative relationship with the Research Council of Norway (RCN), which has co-financed most of our strategic network development. Our strategy of employing the FME research areas as target areas in the development of our international cooperation has been very successful. We now have substantial research activity in these selected areas, which makes us an interesting partner to universities and research institutions worldwide.

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").

In January 2011, the ECCSEL Preparatory Phase project, which is funded by EU and lead by NTNU, was started with Laboratory Director Morten Grønli as coordinator. Its aim is to work out viable options for the legal structure, a governance model, a financial strategy including a business model, an Infrastructure development plan and other elements of a general framework needed so ECCSEL can be in full operation as a pan-European distributed RI from 2015.

Three working groups have been established to work on the following issues:

1. **The legal and governance structure** that will define the legal framework to regulate the operation and management of ECCSEL. This will include analysis of different options of suitable legal forms and to define a governance structure for ECCSEL. It will also set up IPR rules and an access policy
2. **The financial strategy** that will identify funding mechanisms for new investments and operational and trans-

national access costs. It will recommend procedures and mechanisms for the flow of funding through the ECCSEL organization and provide cost scenarios.

3. **The infrastructure development plan**, which will result in a long term plan that will comprise all RI upgrades and new-builds required to meet the needs of the European CCS community. It will be based on a detailed identification of future infrastructure needs, a comprehensive mapping of existing infrastructure and planned developments and on a subsequent gap analysis.

The work in the different groups is progressing well.

The preparatory phase consortium has 15 partners from 10 countries across Europe. In the operation phase, ECCSEL will also involve partners and facilities outside the current preparatory phase project

For more information, visit www.eccsel.org

SEEIT – Strategic Partnership for Sustainable Energy Education, Innovation and Technology

As described in the 2009 and 2010 Annual Report, the SEEIT Consortium, which reached the final round in the competition for a Knowledge and Innovation Community (KIC) in Energy, decided to form a new consortium to carry out its original plans to work together and take initiatives on energy research programmes and education.

This 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 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.

The three working groups and their tasks for the ECCSEL Preparatory Phase project

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

Pro-Rector Johan Hustad represents NTNU on the Steering Committee and a SEEIT network has been developed at NTNU.

The main areas of interest for SEEIT are bioenergy, wind energy, solar energy, energy in buildings, energy efficiency and energy systems, i.e. a strong team on sustainable energy. In 2011 we have worked further to establish the organization and create the following new initiatives:

- Erasmus Mundus application EWEM – "European Wind Energy MSc" was awarded, with Delft University of Technology, Technical University of Denmark, Carl von Ossietsky Universität Oldenburg and NTNU as partners. EWEM aims to educate 120 -150 MSc graduates per year, with a specialization in wind physics, rotor design, electric power systems and offshore engineering. The study programme will be launched in September 2012.
- The SEEIT consortium brought forward an application for EU FP7 Energy.2012.8.1.1: "Next Generation heat pump technologies" based on "Natural working fluids". The application was awarded.
- SEEIT organized workshops on energy efficiency in Rome April 4 and on energy systems in München on October 27-28.
- SEEIT submitted a joint response to EU's Green Paper "From Challenges to Opportunities: Towards a Common Strategic Framework for EU Research and Innovation Funding".
- SEEIT was invited to nominate candidates to the Expert Group that was established to develop the SET-Plan Education and Training Initiative (see below).

SET-Plan Education and Training Initiative

The European Commission has put education and training on the strategic map, realizing that the education of enough specialists in the most important new technology areas will be of utmost importance to realize the goals of the SET-plan. Expert Groups have been set up for 13 areas: Bioenergy, Carbon Capture and Storage, Concentrated Solar Power, Electricity Grids, Energy Efficient Buildings, Energy Storage, Fuel Cells and Hydrogen, Nuclear Energy, Photovoltaics and Wind and Ocean Energy.

By using our connections in EUA-EPUE and SEEIT, NTNU was able to recruit members to seven of these areas, and act as reporter on CCS and Energy grids.

Strategy for further work

NTNU will work more systematically to participate actively in 2012 in the joint initiatives being developed by EERA (European Energy Research Arena), and EPUE (European Platform of Universities Engaged in Energy research, Education and Training).

Japan

Kyoto International Forum for Environment and Energy (KIFEE)

KIFEE, which was founded by Professor Yasuhiko Ito, was originally created for the universities in the Kyoto region to develop an international arena for strategic cooperation between universities working to develop a sustainable society, inspired by the Kyoto Protocol.

When the Bilateral Agreement on Technological Cooperation between Japan and Norway was signed in Tokyo in May 2004, there was a desire to build up a long-term research partnership that could serve as a basis for industrial cooperation.

Norwegian universities were invited to participate in KIFEE because of the long-lasting and good relations between the universities in the Kyoto region and NTNU, initiated by Professor Signe Kjelstrup. Since the bilateral agreement involved interactive research between energy and materials to provide new solutions to build a sustainable future, it was decided to employ KIFEE as platform and arena for the strategic research cooperation. The Research Council of Norway allocated funds for the development of this area, and Innovation Norway made their invaluable network available for the project.

The first KIFEE Symposium was arranged in Kyoto in October 2004. Since then one workshop and four more symposia have been organised successfully in Japan and Norway. The response in both countries has been exceptionally good. The presence of more than 40 Japanese participants at the previous KIFEE meetings in Norway and a similar attendance from Norway at the previous symposia in Japan reflect the substantial commitment from both countries.

It may be concluded that 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.

The 6th KIFEE Symposium, which will be organized in Trondheim in September 2012, will also include a plenary session on Sustainability Science, a topic that was introduced by Hiroyuki Yoshikawa in an excellent and inspiring presentation during the previous KIFEE Symposium in Kyoto in 2011.

Other associated partners have also been included in the "KIFEE-family" of universities and research institutes both from Japan and Norway. Thus the University of Oslo, the University of Bergen and SINTEF have become permanent partners from Norway.

We will cooperate with the Research Council of Norway to create an official role for KIFEE as a strategic institutional cooperation between Japan and Norway in the area of Energy and Environment.

China

The development of long-term strategic cooperation with China in the energy sector started in 2004 in association 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 for 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 a Working Fluid, Carbon Capture and Storage; Renewable Energy; Energy Systems
- Chongqing University
  - Renewable Energy

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

During our successful meeting at Tsinghua University during EXPO 2010, THU and NTNU 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".

The development of the JRC Agreement has been delayed, but we are patiently keeping contact and have taken advantage of different opportunities to visit THU in 2011, and the signal is that a delegation from THU will visit NTNU in 2012, so that JRC cooperation may be realized in 2013.

Shanghai Jiao Tong University (SJTU)
Thanks to efficient cooperation and preparations by both SJTU and NTNU's top management, an agreement on a Joint Research Centre on Sustainable Energy between SJTU and NTNU was signed in May 2010 by SJTU President Jibe Zhang and NTNU Rector Torbjørn Digernes. 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 energy, wind energy, ambient)
- **Energy use in Buildings / Zero Emission Buildings** (energy efficiency)
- **Energy System Analysis and Sustainable Energy Studies**
- **Catalysis in New Energy Technologies**

Thanks to the Research Council of Norway, NTNU was able to secure financing of a preparation project for the JRC which was carried out in 2011 (RCN Project no. 208462). The preparation project made it possible to organize three JRC workshops with high attendance in 2011:

- Workshop 1 in Shanghai 3–5 May 2011: Working groups were created and the creation of working plans and project proposals was begun. Thirteen people from SJTU and 8 people from NTNU as well as Dr. Kari Kveseth, the Norwegian Counsellor of Science and Higher Education at the Royal Norwegian Embassy in Beijing, participated.

- Workshop 2 in Trondheim 19–21 September 2011: Development of further plans and activities and the completion of project proposals that were approved for starting up by the JRC Board. It was decided that these projects will be financed by SJTU and NTNU's own resources, in part because of the determination on the part of both parties to begin real cooperation as quickly as possible. Thirteen people from SJTU and 36 people from NTNU participated, including Dr. Rune Volla, the Director of the Department for Energy Research, Research Council of Norway.

- Workshop 3 in Shanghai 28–29 November 2011: This workshop was dedicated to "Education" and the main objective of the workshop was to discuss and agree upon exchange of students, and more important, the development of a double degree master's programme in sustainable energy. Eight people from SJTU and 5 people from NTNU participated.

The first official JRC Board meeting was organized in Trondheim on 21 September right after the workshop ended. The following issues were addressed:

Representatives at the 2nd workshop 2011 in Trondheim

- Appointment of Professor Arne M. Bredesen, NTNU as Director and Professor Ruzhu Wang, SJTU as Co-director of the JRC.

- Approval and start up of four cooperative PhD projects prepared during the JRC workshop:
  - Group: Energy system analysis
  - Title: "Developing offshore wind industry in and between China and Norway"

  - Group: The Use of CO2 as a working fluid
  - Title: "Development of a concept for utilizing CO_2 as refrigerant in air conditioning and heat pump systems in combination with ground source storage"

  - Group: Process Technology - LNG Technology
  - Title: "Cooling and Condensation of Multicomponent Mixtures for improved LNG Processes"

  - Group: Energy use in buildings
  - Title: "Integrated performance simulation of BIPV/T systems, analyzing their potential to fulfil the energy requirements of a typical residential building in Shanhai and Trondheim, aiming to achieve zero energy/ emission buildings"

More information is available at
http://www.ntnu.edu/jrc/jrc

Chongqing University (CQU)
On May 31 in 2010, an NTNU delegation headed by Pro-Rector Johan Hustad visited the College of Power Engineering at Chongqing 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:

- Bioenergy
- Solar energy
- Fuel Cells (biological)
- Enhanced heat transfer
- Refrigeration and air conditioning

Regrettably we have not had the capacity to follow up on these areas in 2011.

India

In 2011, NTNU's leadership put cooperation with India on the strategic map and a large delegation visited India in February. TSA Energy organized a multidisciplinary "Energy group" and with help and support from Innovation Norway we visited eight selected research and education institutions, three in Chennai and five in Delhi. The main objective of the visits was to exchange information about ongoing research and education, and identify potential areas where cooperation could be developed.

Based upon the reports we decided to start up development of long term cooperation with IIT Madras, IIT Dehli, TERI (The Energy and Resources Institute) and Murugappa Research Centre (MCRC). The working areas selected in the first phase were "Sustainable Habitat – Green Buildings", "Membrane Technology" and "Carbon Capture and Storage".

During NTNUs multicultural event "India Week" in October we were able to organize a successful one-day energy seminar on "Green Buildings, with participants from NTNU, TERI and MCRC. TERI with its "Centre for Research on Sustainable Building Science (CRSBS), and NTNU with its FME on "Zero Emission Buildings" are excellent partners. Based on thorough presentations on ongoing activities the participants agreed upon that the two first cooperation projects within "Green Buildings" should be "Climate-adapted Low Energy Building Envelope Technology" and "Zero Emission Cabin for Tropical Climate". These activities will also include Industrial Ecology, and we plan to carry out workshops in India in the autumn of 2012 to plan specific projects.

USA

In May 2004, the USA and Norway signed an MoU on research cooperation in the energy sector, with a special emphasis on CO2 management, hydrogen fuel and new energy technology. NTNU has since then developed a 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 (PPP = Paired Professors and PhD students). This programme involved three projects: "Gas transport systems", "CO2 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 related to "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 2012 we hope to be able to start 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 2011
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 2011, the Science Week was organized at UC Berkeley and Stanford University on October 25 - 27, under the title of "Innovation Frontiers". The programme included the following topics:

- Renewable energy and climate issues
- Marine Science and Oceans Monitoring
- Space Science
- Education Science
- Microelectronics and Nanotechnology
- Big ICT Systems
- Role of Universities in education

NTNU participated with a substantial delegation headed by Rector Torbjørn Digernes and Pro-Rector Kari Melby.

The energy groups were engaged in the following areas (all well connected to our FMEs):

- Climate change and the energy technology perspectives
- Green Buildings
- Bioenergy
- Solar Energy

- Offshore Wind
- Climate and CO_2 Management

It should be mentioned that our "Zero Emission Buildings" team has enjoyed successful cooperation with Lawrence Livermore National Laboratory over the long term, so the participation within that area was rather extraordinary.

South Africa

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 ran successfully and formed the basis for an application for a 2-year master's programme project approved in spring 2011. This project consists of four different types of activities:

1) Development of MSc programmes by including CCS specific courses
2) PhD programme
3) Industry course on CCS
4) Exchange of personnel

In the autumn of 2011 preparatory work took place, including employment of PhD candidates. The project activities start in 2012 and finish in 2014. This project 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 on energy education with universities in the Balkan countries. 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.

The project consists of three main activities: development of MSc programmes, implementation of MSc programmes and dissemination directly to energy sector in the western Balkans.

Development: Development was the main issue during the entire first year of the project. After the kick-off meeting for the project was held in Belgrade in November 2010, the real work started with a rather intensive period of knowledge transfer regarding rules and practical matters related to development of curricula in accordance with the Bologna Declaration. Three workshops were held with the focus on these issues (Tuzla in February, Zagreb in April and Sarajevo in May).

Implementation: The first pilot classes of students have been enrolled during the autumn semester at three universities:

- University of Sarajevo: 21 students, of which 5 are female (24%)
- University of Tuzla: 17 students, no females (0%)
- University of Zagreb: 17 students, of which 7 are female (41%)

The project is expected to start at the University of Belgrade and University of East Sarajevo in the autumn of 2012.

Dissemination: Development of curricula for new MSc study programmes was a very challenging process that required a great deal of work. This resulted in a delay in planning for dissemination of knowledge to industry through seminars and specialist courses. The planning work started at the workshop held in Belgrade in December and will be continued in 2012.

International cooperation on petroleum (BRU)

As can be seen from the report from the Centre for Better Resource Utilization of Petroleum (BRU), this community has developed an impressive cooperative network with a wide range of international partners that work with hydrocarbon issues. The current key countries are Angola, Bangladesh, Brazil, Canada, France, Italy, Mozambique, the Netherlands, Nigeria, Russia, Spain, Tanzania, 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 teams 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 multi-disciplinary 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).

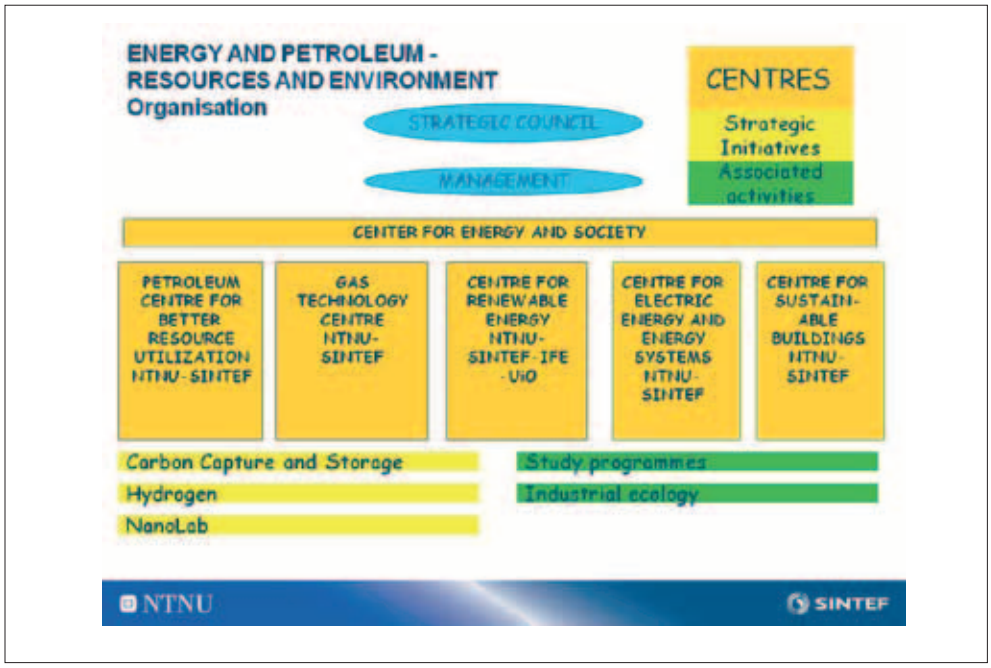
- We may also have a competitive edge in the European Research Area and strategic international cooperation.

- 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 2011

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:

- Industrial Ecology Programme("IndEcol"): Professor Edgar Hertwich
- Carbon Capture and Storage: Professor Olav Bolland
- Hydrogen Technology: Professor Hilde Venvik
- Study programme Energy & Environment: Professor Vojislav Novakovic
- Research Infrastructures: Laboratory Director Dr. Morten Grønli

Strategic area management:

- Director: Professor Arne M. Bredesen
- Associate Director: Dr. Trond Kvilhaug
- Secretariat: Anita Yttersian

Strategic Council:

- Ingvald Strømmen, NTNU (leader)
- Anne Kathrine Slungård, Ungt Entreprenørskap Norge
- Bjørg Andresen (spring) / Arve Holt (fall), IFE
- Eli Aamot, Statoil
- Hans Jørgen Roven, NTNU
- Snorre Valen, Stortinget
- Nils Kristian Nakstad, Enova
- Per Ola Ulseth, Skanska Norge AS
- Steinar Asbjørnsen, Statkraft

- May Britt Myhr, SINTEF Petroleumsforskning AS
- Sverre Aam, SINTEF Energiforskning AS

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 electro catalysts 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 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 FP7 Energy projects at NTNU and SINTEF

No.	Project	Area	Programme
1	BRISK	Bioenergy	FP7-INFRASTRUCTURES-2011-1
2	GreenSyngas	Bioenergy	FP7-ENERGY-2007-1-RTD
3	CESAR	CCS	FP7-ENERGY-2007-1-RTD
4	DECARBit	CCS	FP7-ENERGY-2007-1-RTD
5	ECCO	CCS	FP7-ENERGY-2007-2-TREN
6	ECCSEL	CCS	FP7-INFRASTRUCTURES-2010-1
7	iCap	CCS	FP7-ENERGY-2009-1
8	OCTAVIUS	CCS	FP7-ENERGY-2011-2
9	SUSHGEN	Fuel cells	FP7-PEOPLE-ITN-2008
10	WELTEMP	Fuel cells	FP7-ENERGY-2007-1-RTD
11	CREEA	Industrial ecology	FP7-ENV-2010
12	PROSUITE	Industrial ecology	FP7-ENV-2008-1
13	OPEN: EU	Industrial ecology	FP7-ENV-2008-1
14	MaRINET	Offshore renewables	FP7-INFRASTRUCTURES-2010-1
15	HiPRwind	Offshore Wind	FP7-ENERGY-2010-1
16	MARINA	Offshore Wind	FP7-ENERGY-2009-1
17	ORECCA	Offshore Wind	FP7-ENERGY-2009-1
18	WAVETRAIN 2	Wave energy	FP7-PEOPLE-2007-1-1-ITN
19	EFFESUS	Energy in buildings	FP7-NMP-ENV-ENERGY-ICT-EeB-2012
20	RAMSES	Energy in buildings	FP7-ENV-2012
21	ZenN	Energy in buildings	FP7-NMP-ENV-ENERGY-ICT-EeB-2012
22	Retrokit toolbox	Energy in buildings	FP7-NMP-2012-2
23	Locoefficient	Energy in buildings	FP7-NMP-EeB-2012-3

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/

Produksjon: www.tagtrykk.no Miljømerket trykkeri, lisensnr. 241 811

Annual Report for Energy and Petroleum 2011

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

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