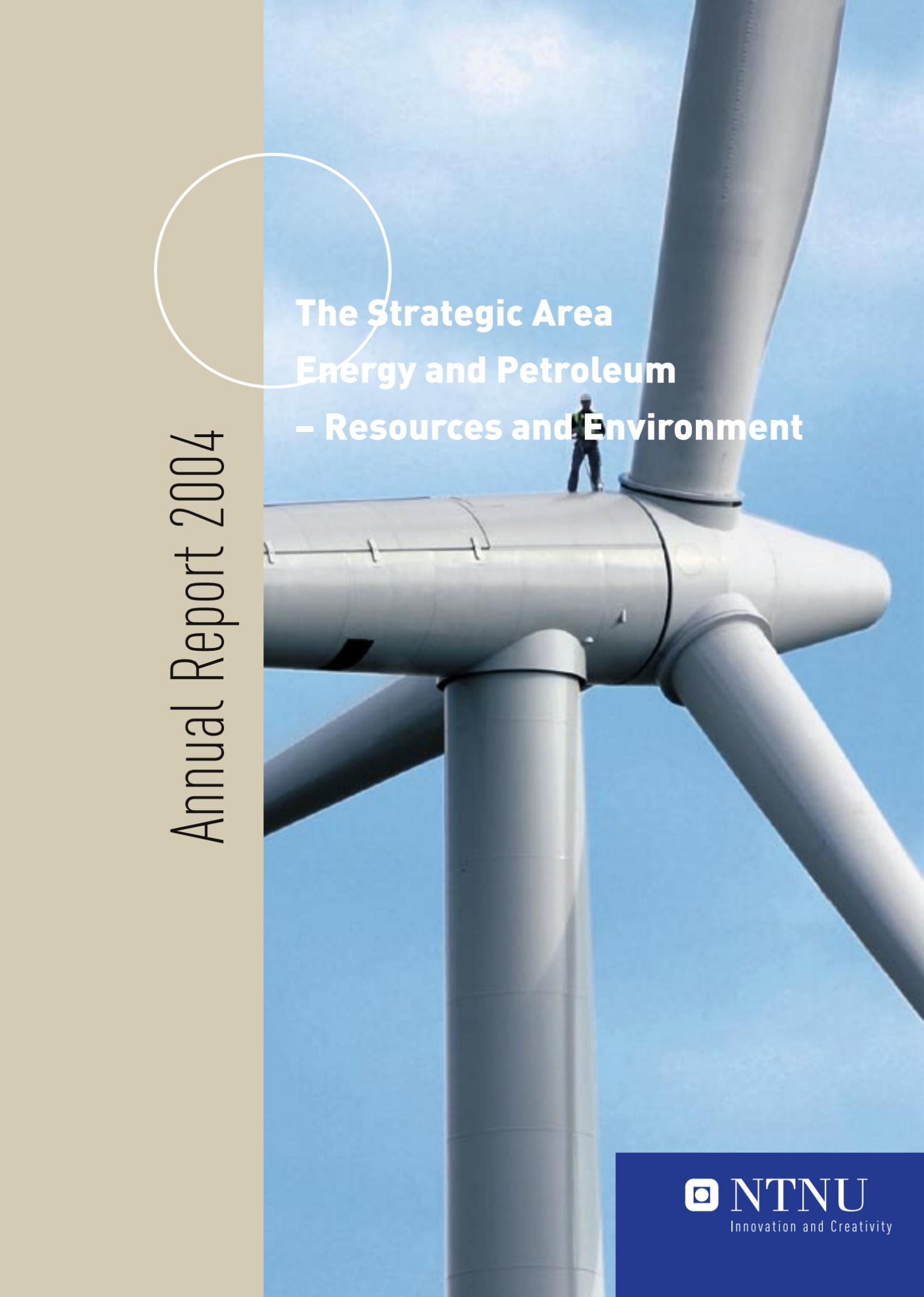


Annual Report 2004



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

## What are the Strategic Areas at NTNU?

One of the main goals of NTNU is to be useful to society, by developing and maintaining the national technological skills needed to build a sustainable society. To realize this goal NTNU has given priority to six strategic areas where we aim to be among the internationally leading universities. These are:

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

Visit us at [www.ntnu.no/satsingsomraader/eng/](http://www.ntnu.no/satsingsomraader/eng/)

## About Energy and Petroleum – Resources and Environment

Our vision is “Technology for a sustainable future”. The overall goal of our research and education is to contribute to global innovation and develop new knowledge, technology and economic solutions that will be useful to society and that will make it possible to meet future energy demands in a sustainable way. We work in close cooperation with our research partner SINTEF. More than 750 people at NTNU-SINTEF are involved in our activities, including 240 doctoral students and postdocs. In addition we educate more than 250 Master’s degree candidates for the energy sector each year. The area is organised into six goal-oriented multi-disciplinary teams:

- Smart Energy Efficient Buildings
- Centre for Renewable Energy
- Gas Technology Center
- Better Resource Utilization (Petroleum)
- Energy System Analysis
- Energy and Society

The guidelines for our research are based on the following overall strategies:

- Increase the efficiency of end user energy consumption
- Contribute to improved resource use on the Norwegian continental shelf in the whole technology chain, from source to end user
- Support technological development of “clean” electricity and hydrogen as the dominant energy carriers of the future
- Develop systems and technologies to improve the availability and efficiency of these energy carriers
- Support technological development to use natural gas (with its high hydrogen content) as an energy source to produce electricity and hydrogen until sufficient renewable energy sources are available (natural gas as a “path” to a renewable society)
- Develop systems and technology to promote and integrate renewable energy sources
- Integrate energy, technology and societal topics in our education, research and innovation
- Develop a flexible and robust organisation able to meet the future’s new research challenges

Visit us at: <http://www.ntnu.no/em/>

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– Resources and Environment

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## Main events in 2004

- In August, NTNU merged Energy and Environment with its substantial Petroleum research group and created the new Strategic Area “Energy and Petroleum – Resources and Environment”. This enables NTNU to manage the whole chain of energy challenges, from source to end user, in a comprehensive way.
- The official opening of the new Centre for Renewable Energy NTNU-SINTEF (SFFE) was observed by staging an international seminar with 120 participants on June 17-18.
- SINTEF researcher Dr. Hilde Venvik became the first full-time NTNU hydrogen professor.
- The Research Council of Norway initiated two new energy research programs “Renergi” and “Petromaks”. NTNU and SINTEF were successful in the first round of applications.
- The “Renergi” program has granted a pool of ten PhD scholarships for NTNU, to be shared by our two Centres of Gas Technology and Renewable Energy.
- SmartBuild organized two successful workshops “The Smart Building in 2020” and “Integrated Design Process for Smart Energy Efficient Buildings”.
- The Centre for Better Resource Utilization (BRU) project was started at NTNU to strengthen and focus research and development aimed at better exploration and production of oil and gas from the Norwegian continental shelf.
- The NTNU informational film, “The Road to the Hydrogen Society” was produced.
- The start up of innovation activity and cooperation with NTNU Technology Transfer AS. In 2004, 35 ideas were registered, leading to 7 commercialization projects and the creation of 3 firms.
- The strategic area carried out a foresight study on CO2 management that will be used in further development of this strategically important activity and in preparation for the EU’s Seventh Framework Programme.
- The first Kyoto International Forum for Environment and Energy Symposium (KIFEE) Materials and Processes for Environment and Energy was organized in Kyoto, Japan, on November 14-17 and the Kyoto Norway Center was opened.
- A team of six representatives from NTNU-SINTEF participated in the Norway-US Science and Higher Education Week in Washington in October with six presentations in different conferences and workshops.
- A total of 300 publications and 50 communication initiatives were delivered by scientists in the strategic area.

## Our most important partners are:

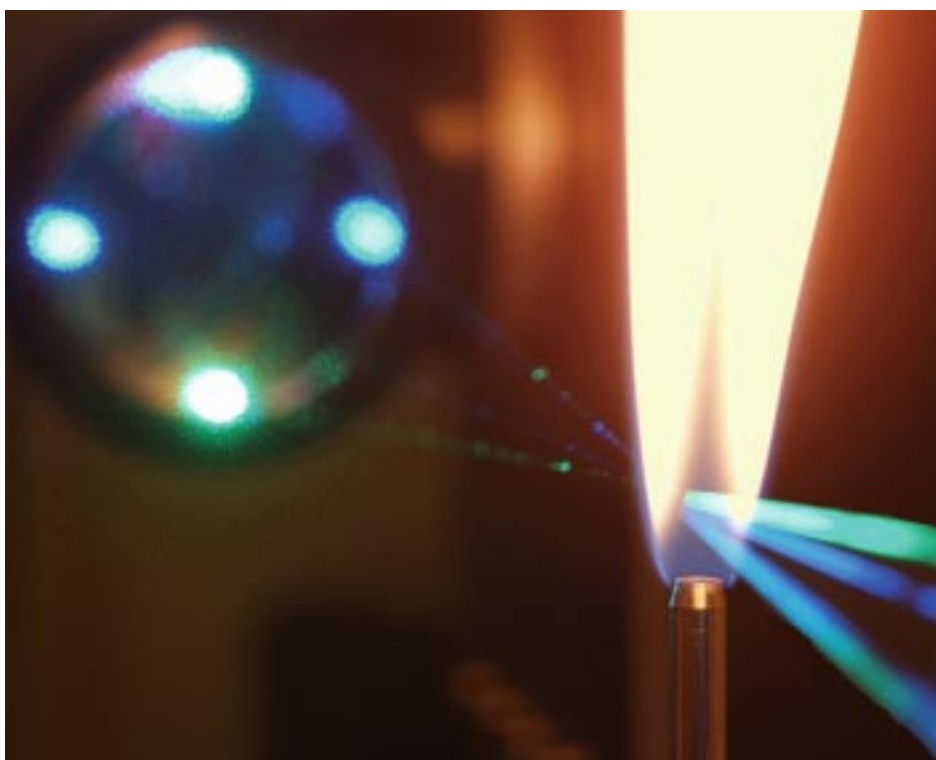
- Parliament Committee on Energy and Environment
- Ministry of Petroleum and Energy
- Ministry of the Environment
- Ministry of Trade and Industry
- Research Council of Norway
- Innovation Norway
- Enova (public energy enterprise)
- Statsbygg (Directorate of Public Construction and Property)
- NVE (Norwegian Water Resources and Energy Directorate)
- FOPUT (regional petroleum policy group)
- Industry Innovation Fund for NTNU
- STATOIL
- HYDRO
- Renewable Energy Corporation (REC)
- SHELL
- Statkraft (public power company)
- Statnett (public power grid owner)
- Statsbygg (public property manager)

## EU Framework projects at NTNU and SINTEF

- ENGAS RI (Environmental Gas Management Research Infrastructure): 900,000 Euro
- NATURALHY (Road to hydrogen society): 437,000 Euro
- FURIM (Fuel cell development) 430,000 Euro
- CASTOR (Storage, capture and transport of CO<sub>2</sub>) 3,450,000 Euro
- ENCAP (Capture of CO<sub>2</sub>) 2,900,000 Euro
- CO<sub>2</sub>GeoNet (Network of Excellence in Geological Storage of CO<sub>2</sub>) 800,000 Euro
- INCACO<sub>2</sub> (International cooperation CO<sub>2</sub> capture and storage) 100,000 Euro

## New Research Council of Norway projects in 2004

- Combined Strategic University Program (SUP) and Strategic Institute Program (SIP) on "Geophysics and Petrophysics"
- The enabling of production of remote gas (currently inaccessible gas reservoirs)
- Participation in the International Energy Agency (IEA) Bio-energy Agreement Task 32I
- Technology development for integrated solid oxide fuel cell (SOFC), biomass gasification and high temperature gas cleaning
- Clean energy through the use of high performance membranes
- Thermal effects in polymer electrolyte fuel cells
- New process technology for the production of hydrogen from natural gas
- Providing hydrogen for transport in Norway – A social learning approach
- Efficient hydrogen liquefaction processes
- Novel solid CO<sub>2</sub> absorbents and their application at high temperatures and high pressures
- CO<sub>2</sub> management technologies for future power generation – BIGCO<sub>2</sub>



LDV-laser measurement in flame. Photo: ENGAS/Morten Grønli.

## ENERGY AND PETROLEUM – RESOURCES AND ENVIRONMENT IN 2004

The successful development of the strategic area has continued in 2004, under the strategic leadership of the Board. Since the Industry Innovation Fund for NTNU financed the first project in January 2000, more than 140 new PhD scholarships and postdoctoral positions have been created. The Research Council of Norway has been the most important partner and sponsor, together with NTNU's own strategic resources.

Today, the new research activity that is underway represents annual funding on the order of NOK 100 million. This has been made possible by strategic "seed grants" from NTNU of altogether NOK 5 million since the programme's beginnings in January 2000.

building energy needs with considerably reduced resource consumption and environmental impact. The principal idea is that the development and implementation of smart, energy-efficient buildings requires a focus on the whole that can only be obtained through interdisciplinary cooperation, which is why teamwork between architects, engineers and social scientists is needed in this project. The exchange of ideas across disciplines is a major focus of the group. Important research fields are:

- User needs, environmental criteria and strategies for the implementation of smart energy-efficient solutions.
- Energy systems integrated in buildings and integrated design processes.
- Daylight systems, photovoltaic systems, heat pump systems, energy storage, and efficient control and automation systems.

## CENTRE FOR RENEWABLE ENERGY NTNU-SINTEF

To support our central strategy and promote the availability and marketability of renewable energy sources, the new Centre for Renewable Energy NTNU-SINTEF (SFFE) was officially opened with an international seminar on June 17-18 2004. One hundred and twenty participants were present when the State Secretary of the Ministry of Petroleum and Energy opened SFFE, and 25 invited speakers presented their work.

The goal of the activity within the Centre is to contribute to public and political understanding of the importance of increased use of renewable energy in society, as well as contributing to strategies and new knowledge for the innovation and development of new technologies for increased exploitation of renewable energy resources in cooperation with Norwegian industry. (<http://www.ntnu.no/sffe/>)



WHICH ROAD TO TAKE? Left: "Natural gas road" or right: "Renewable energy road"? (Photo from "The Road to the Hydrogen Society". Director: Ragnhild Krogvig Karlsen).

## SMART, ENERGY-EFFICIENT BUILDINGS (SMARTBUILD)

The SmartBuild group aims to develop new knowledge, integrated solutions, and technologies that make it possible to meet

**Research is being conducted on a range of technologies and issues related to renewable energy:**

- Solar energy – Production of Power (solar cell silicon) & Heat
- Hydropower
- Wind Energy (Strategic program)
- Bio energy
- Energy from the ocean (tidal, wave, salt gradients)
- Ambient heat (used by heat pumps to cover low value heating demand)
- Geothermal energy
- Hydrogen technology for energy storage and conversion
- Energy system integration
- Social, economical and political issues

**Results from 2004:**

- A competence centre on “Solar energy for silicon based PV technology” has been developed by NTNU, SINTEF and Institute for Energy Technology (IFE)
- A test station for wind power is under construction at Valneset in Sør-Trøndelag. The station is owned by NTNU, SINTEF and IFE.
- A new “Wind power laboratory” has been developed.
- A laboratory electrolysis cell based on PEM electrolytes has been developed, producing hydrogen from renewable energy with very high efficiency.
- An energy storage/conversion laboratory has been developed by SINTEF and NTNU, for the study of hybrid power systems based on renewable energy, where hydrogen is used for storage.
- An initiative has been taken to restart research on harnessing ocean wave energy.

**GAS TECHNOLOGY CENTER  
NTNU-SINTEF**

The Gas Technology Center NTNU-SINTEF unites the combined efforts of NTNU and

SINTEF. It opened in 2003. The goal is to improve the natural gas value chain through multidisciplinary research and teamwork. The centre has 300 affiliated researchers, and 80 to 90 per cent of the centre’s research activity is externally funded. Internal and external resources for NTNU and SINTEF total NOK 100 million per year. ([www.ntnu.no/gass/](http://www.ntnu.no/gass/))

**Research is conducted on a range of technologies and issues related to natural gas use:**

- Reservoir technology (including CO<sub>2</sub>-injection)
- Transport (multiphase pipelines and liquefied gas – LPG, LNG, LCO<sub>2</sub> and LH<sub>2</sub>)
- Processing (fractionating, dew point control, compression)
- Chemical conversion (syn-gas production, polyolefines) and power generation from natural gas (gas turbines, fuel cells, CO<sub>2</sub>-management)
- Hydrogen from natural gas (production, transport, storage and end use)
- Coordination of the natural gas value chain in liberalized energy markets
- Societal issues

**Results from 2004:**

- New projects were begun, such as “Enabling of remote gas” and “Optimal design and operation of gas processing plants” with a budget of over NOK 50 million during 2005–2008.
- New EU Framework Programme projects in CO<sub>2</sub> and hydrogen technology were initiated and new project proposals were submitted. The total budget for EU-projects at the Center for the period 2004–2008 is 9 million Euro.
- SINTEF researcher Dr. Hilde Venvik became the first full-time NTNU hydrogen professor.
- The world’s largest CO<sub>2</sub> conference (GHGT-8) - scheduled for June 2006 - will be organized by The Gas Technology Center NTNU-SINTEF.



*Professor Jon Kleppe is the leader of Centre for Better Resource Utilization (BRU).  
Photo: NTNU Info.*

## **CENTRE FOR BETTER RESOURCE UTILIZATION (BRU)**

The integration of exploration and production of oil and gas into the strategic area in 2004 has added more than 50 PhD and postdoc researchers and 30 professors to the strategic research community. New areas of research include geology, geophysics, petrophysics, drilling, production and reservoirs, all aimed at better exploration and production of oil and gas. The centre will develop a focused research strategy through discussions with the oil industry, service companies, organizations, the Research Council of Norway and governmental agencies. A total of 50 visits have been included in this fact-finding mission, which will be concluded with a national seminar in Trondheim August 22-23, 2005.

A new Strategic University Program (SUP) was awarded by the Petromaks program in 2004, in the area of geophysics and petrophysics, and two related Strategic Institute Programs (SIP) were awarded to SINTEF Petroleum Research, for a combined value of close to NOK 50 million over a period of five to six years.

## **ENERGY SYSTEM ANALYSIS**

The introduction of deregulated electricity and gas markets offers a significant challenge for the transition to a sustainable and flexible energy infrastructure. The traditional long-term planning activities of governments and monopoly utilities have been severely diluted, causing potential gridlock and under-investment in energy infrastructures, with significant economic and social consequences.

The Energy System Analysis group wants to find solutions to these challenges.

To this end, NTNU and SINTEF are running the coordinated projects SEDS (Sustainable Energy Distribution Systems) and E-transport (Analysis of Energy Transport Systems with Multiple Energy Carriers). The main objective of this combined effort is to develop a scientifically based framework for the planning of mixed energy distribution systems, including methods and models for optimal integration of different energy sources and carriers within the existing electric power system infrastructure. In 2004 some early results were published both nationally and internationally (PhD studies).

On a more global scale, the TRANSES program (Transitions to Sustainable Energy Services in Northern Europe) has been developing during 2004 with contributions from MIT, Chalmers University of Technology in Sweden, and SINTEF. A set of six main scenarios for the energy supply system of the future have been constructed and quantified through initial energy market simulations. TRANSES was presented at the Norway-U.S. Science & Higher Education Week in Washington, D.C., October 4 – 6, 2004.

Within the Energy System Analysis group, there are ongoing research activities in the field of wind power and hydrogen energy storage. Our main objective is to develop new methods for evaluating the viability of using hydrogen storage for increasing the penetration and value of wind power in the power system.

## **ENERGY AND SOCIETY**

The development of sustainable energy production and use are major challenges for Norwegian society, related to cultural and political issues and the need to develop

strategies for the social accommodation of new energy solutions. This research group will contribute to the strengthening of our knowledge base to develop strategies to construct more environmentally friendly energy policies at both a national and international level. This will be achieved by analysing the economic and cultural dimensions of energy use in dwellings and businesses, the social aspects of the development of new energy technologies, and political and financial strategies to achieve sustainable production and consumption of energy.

### INNOVATION AND ENVIRONMENTAL CHANGE

This research group is focused on new solutions and technologies to help society in developing a sustainable future. Some of these new products will be developed and brought to the national and international markets by Norwegian industry, broadening the country's industrial base and

creating new jobs in Norway. We work with the NTNU Technology Transfer Office AS, and the Industry Innovation Fund for NTNU in pursuing such efforts.

This group is still in its start up phase. As a first step we are evaluating existing barriers and driving forces with respect to technological changes.

### ENGAS RESEARCH INFRASTRUCTURE

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



*THE POWER OF WIND: An increasing number of countries are investing in wind power. Photo: Statkraft*



*Professor Arne Bredesen is the director of the strategic area of Energy and Petroleum – Resources and Environment. Illustration: NTNU Info/Rune Petter Ness*

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

## ACHIEVEMENTS IN INTERNATIONAL COOPERATION

The strategic area's board has emphasised international cooperation, giving priority to regions and countries where Norway has developed industrial cooperation: the European Union, Asia (Japan and China) and North America. Activity in all these regions in 2004 has been significant.

The long-term strategic work to establish NTNU and SINTEF as significant contributors to European research has continued successfully in 2004, with the start up of Integrated Projects, Networks of Interest and Research Infrastructures with a total budget of 9 million Euro. We have also brought forward proposals for new large Integrated Projects together with industry for the Sixth Framework Programme, and started preparations for the Seventh.

Supported by the Research Council of Norway and Innovation Norway (a public industrial development company) in Tokyo, we planned and carried out the first KIFEE Symposium "Materials and Processes for Environment and Energy" in Kyoto 14-17 November, together with our Japanese colleagues. The KIFEE symposium attracted 114 participants from KIFEE-universities and industry, 90 from Japan and 24 from Norway. Fifty papers were presented and discussed at the symposium, which also featured special workshop sessions where future cooperation was discussed. The first symposium was opened by the Norwegian ambassador and NTNU's Rector, who also officially opened the Kyoto Norway Center at Doshisha University in Kyoto.

Activity in 2004 in China started with a research study tour March 20-27, organised by Innovation Norway in Beijing, where we visited selected universities and research institutes in Beijing, Shanghai,

Zhejiang and Guanzhou. We were also invited to participate in the "2004 China Norway Conference" October 10-12. During the energy workshop "Challenges in the Energy Sector", NTNU gave a presentation on "Strategies for a Cleaner Energy Future" and produced a summary together with Innovation Norway, where possible areas for future research cooperation were described.

In May 2004, the USA and Norway signed a Memorandum of Understanding (MoU) on research cooperation within the energy sector, with a special emphasis on CO<sub>2</sub> management, hydrogen, and new energy technology. NTNU is prepared to take an active part in this innovation by developing strategic cooperation with selected universities. MIT and the University of Maryland have been given priority in the first phase.

Since 2002, NTNU has worked successfully to develop strategic cooperation with MIT and its Laboratory of Energy and the Environment. Thus in 2004 we started the energy system project TRANSES (Alternatives for the Transition to Sustainable Energy Systems in Northern Europe), which involves Hydro, Statoil, Shell, Statsbygg, Enova, Statkraft and Statnett as sponsors. MIT, Chalmers, NTNU and SINTEF are research partners. In 2004 we visited the University of Maryland three times and organised research seminars to identify areas of special interest for cooperation.

The Norway-US Science and Higher Education Week in Washington in October is an important annual meeting place for the strategic area. In 2004 NTNU-SINTEF participated with a team of six specialists, which contributed actively with presentations in all energy-related events. At the Norway-US Workshop "Cooperation on New Energy Technologies & Environmental Research", the TRANSES

project and our cooperation with MIT and the University of Maryland were presented. Other specialists from the Gas Technology Center participated in a US-Norway Planning workshop in New Orleans in May.

The new Petroleum family has established strong cooperative ties with major partners in the US, Holland and Brazil, and also with developing oil-producing countries, such as Iran and India. In 2004, NTNU also became a partner in the oil industry organization INTSOK, which promotes Norwegian technology abroad.

## WHAT IS THE ADDED VALUE OF THE STRATEGIC AREA ARRANGEMENT?

- Better interplay among disciplines. Strategic Areas allow for better communication and enable each individual area to keep informed of activities within other disciplines.
- Walls between disciplines are broken down and new cross-disciplinary arenas emerge.
- Cross-disciplinary research is better suited to industry needs. A Strategic Area opens up opportunities for the commercialization of research results.
- Strategic Areas increase the opportunities for external funding for research projects.

## BOARD

- Senior Vice President Bjørn Sund: Norsk Hydro (Chairman)
- CEO Eli Arnstad: Enova
- Director of Strategy Dag Vareide: Statoil
- Research director Stein Rognlien: Statsbygg
- Technical director Erik Sauar: REC ASA
- Executive Officer Sverre Aam: SINTEF Energy Research AS
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- Professor Hans H. Faanes: Faculty of Information Technology, Mathematics and Electrical Engineering, NTNU Management
- Gas Technology Center, NTNU-SINTEF: Professor Bjarne Foss
- Exploration and Production of Oil & Gas (BRU): Professor Jon Kleppe
- Energy System Analysis: Professor Arne T. Holen
- Energy and Society: Professor Knut H. Sørensen
- Innovation and Environmental Change: Dr. Harald Gether
- Study programme Energy & Environment: Professor Olav Bolland
- The Industry Innovation Fund at NTNU: Professor Arne M. Bredesen
- Strategic contact with SINTEF: Per-Erling Frivik

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- Centre for Renewable Energy NTNU-SINTEF: Professor Johan E. Hustad
- Director: Professor Arne M. Bredesen ([arne.m.bredesen@ntnu.no](mailto:arne.m.bredesen@ntnu.no))
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- Secretariat: Anita Yttersian ([anita.yttersian@ntnu.no](mailto:anita.yttersian@ntnu.no))



*WAVE ENERGY. Centre for Renewable Energy NTNU-SINTEF [SFFE] opened in June 2004 with an international seminar. A symbolic "wave" - performed by representatives from NTNU, SINTEF and the Ministry of Petroleum and Energy - officially opened the centre. Photo: NTNU Info/Tor H. Monsen*

# Annual Report for Energy and Petroleum 2004



## **NTNU – Innovation and Creativity**

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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