Risø DTU Annual Report 2008

Highlights from Risø National Laboratory for Sustainable Energy, DTU

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Risø DTU
Nationallaboratoriet for Bæredygtig Energi

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Edited by Birgit Pedersen and Henrik Bindslev
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Risø celebrates its 50th anniversary. Lectures are transmitted live from risoe.dtu.dk. "Energy for the future – with Risø from nuclear power to sustainable energy" is published.

Among the speakers was one of Risø's founders, Dr. Techn. Haldor Topsøe (picture below).

"Within research and development in wind energy Risø is number one in the world. At second and third places there are none and thereafter come all the rest." Henrik Stiesdal, CTO in Siemens Wind Power.

Preface

"Risø DTU contributes to research, development and international exploitation of sustainable energy technologies, and strengthens economic development in Denmark".

Rarely has Risø's mission been so central to the main challenges our society faces, and rarely has there been such clear awareness in the population of what these challenges are, and such an expressed will to act.

With the work of the UN panel on climate change there has already some time been scientific consensus that the development in the climate is not sustainable and it is mainly due to human activity.

This awareness is now also widespread in the population. In December 2008 the Danish newspaper Politiken on its front page published a poll showing which problems the Danes found it was most pressing to do something about. The three top priority issues in ordered sequence were the financial crisis, the climate and the health sector.

So, is there the political will to act? The Danish Prime Minister certainly devoted half his New Year speech to discussing the climate, why and how we will accelerate green and sustainable development and how this will help pull us out of the financial crisis.

That these are not empty words is evidenced by the fact that in Denmark climate friendly technologies is one of the fastest growing exports and with a volume of 50 billion Danish kroner in 2008 it is already a significant sector.

The mission of Risø DTU, development of climate friendly technologies and creating jobs and industrial development in Denmark, is thus perfectly directed at addressing the two challenges the Danes are most concerned about, namely the financial crisis and the climate.

The third, health, we actually also contribute to through our nuclear activities.

The past year shows that we truly devote ourselves to these objectives. In this Annual Report we give some highlights from 2008. More information can be found at risoe.dtu.dk.

In June 2008 we celebrated Risø's 50 year anniversary. Risø opened on June 6, 1958 with one formidable mission: Denmark's new nuclear research centre was to help reduce the country's dependence on imported energy and strengthen industrial opportunities and competitiveness.

At its 50th anniversary Risø DTU contributes in full measure to this mission. Only today it is not about one technology but a palette of sustainable energy technologies.

Henrik Bindslev

Director

Wind energy – a visionary match

Risø develops wind energy through research and innovation into key areas such as meteorology, wind turbine technology, power system integration and materials.

In addition we are involved in test and measurements, standards and certification, training as well as international projects. The research takes place in cooperation with the wind turbine industry.

Experimental Research Facility for Blade Structure

November 2008, a new research facility at Risø was inaugurated. Here scientists are able to experiment with different physical loads on wind turbine blades, corresponding exactly to what the wind blades experience during a lifetime. The advanced measurements of structural response make new research focused on design and structure possible, thus contributing to the development of larger and stronger blades.

There is room for a 30-40m wind turbine blade in the facility. SSP Technology A/S has donated a 34m blade and the blade has been mounted with a broad range of measuring equipment, which differ significantly from the way commercial tests traditionally are performed today.

Modeling of gusts for load protection

To build better blades, turbines and wind farms we need to improve our insight into how the wind behaves. The fact is that it doesn't just blow. The wind is turbulent and full of gusts which wear down the wind turbines. And it is worse in hilly terrain and where other wind turbines disturb the flow.

With this in focus, Risø has recently extended its models with detailed modeling of gusts. The models are part of WAsP Engineering, a computer program developed and maintained at Risø for the estimation of extreme wind speeds, wind shears, wind profiles, and turbulence in complex terrain.

Wind in complex terrain

In the understanding of the complicated behaviour of the wind it is essential that models and theory are challenged and inspired by experimental observations. That is why researchers from Risø invaded the little island of Bolund just north of Risø and took a wealth of valuable measurements of the wind in this slightly hilly terrain.

The Bolund experiment is a field campaign that provides a new data set for validating numerical models of flow in complex terrain. An increasing number of wind farms are being installed in complex terrain. However, many of the computational fluid dynamics (CFD) tools used to predict the wind flow have only been developed for simple terrain and are often evaluated against such.

In order to validate the numerical models, full scale field experiments with realistic complex terrain forms are necessary. The Bolund data set allows just such a validation. During the campaign in 2007 and 2008, velocity and high frequency turbulence data were collected simultaneously from 35 anemometers distributed on 10 masts, thereby generating a large database designed to validate CFD codes.

Laser wind scanner

The Bolund measurements were taken with conventional meteorology masts. In the future Risø will perhaps take such measurements with a laser wind scanner.

The wind scanner project at Risø is meant to assist the wind industry with new and easy accessible wind speed measurement devices based on remote sensing with lidars. Mounted on the ground sets of lidars can scan the wind field, and mounted in the turbine's nacelle or hub, Wind-LIDARS measure the wind speed immediately in front of the turbine, and detect approaching wind gusts and negative strong wind shears before they reach the rotor plane.

In 2008 the first successful measurements were taken with the lasers which will be part of the full scale laser wind scanner.

Wind turbine generator with superconductors

The development of a generator with superconductors for use in large wind turbines is a relatively new endeavour at Risø.

January 21

North China Electric Power University (NCEPU) appoints four wind energy researchers from Risø as visiting professors for 3 years.

April 30

In cooperation with Risø DTU and "DS Håndværk & Industri" VE-Net invites to the conference and workshop "Biomass and local energy production - now we start, but how?"

High temperature superconductors offer new possibilities by reducing weight and volume of the generator and improved performance but need to be cooled to low temperatures with little use of energy. Here thermoelectric devices, where current may be used to pump away heat, may be an interesting technology.

Risø has obtained new knowledge with neutron scattering that gives insight into how a truly good thermoelectric material might be constructed (see Nature Materials, vol. 7, iss. 10, pp. 811-815, 2008), and collaborators have found new advanced materials (see Europhys. Lett. vol. 80, 17008, p1-p5, 2007) that open for this development.

Composite materials for wind turbine blades

Risø has many years of experience with the so-called fibre composites consisting of polymers and various types of fibres, when it comes to characterization and optimizing the properties and the processing of the materials. Risø contributes with this knowledge in "Blade King", a major project that is going to halve the production time for wind turbine blades.

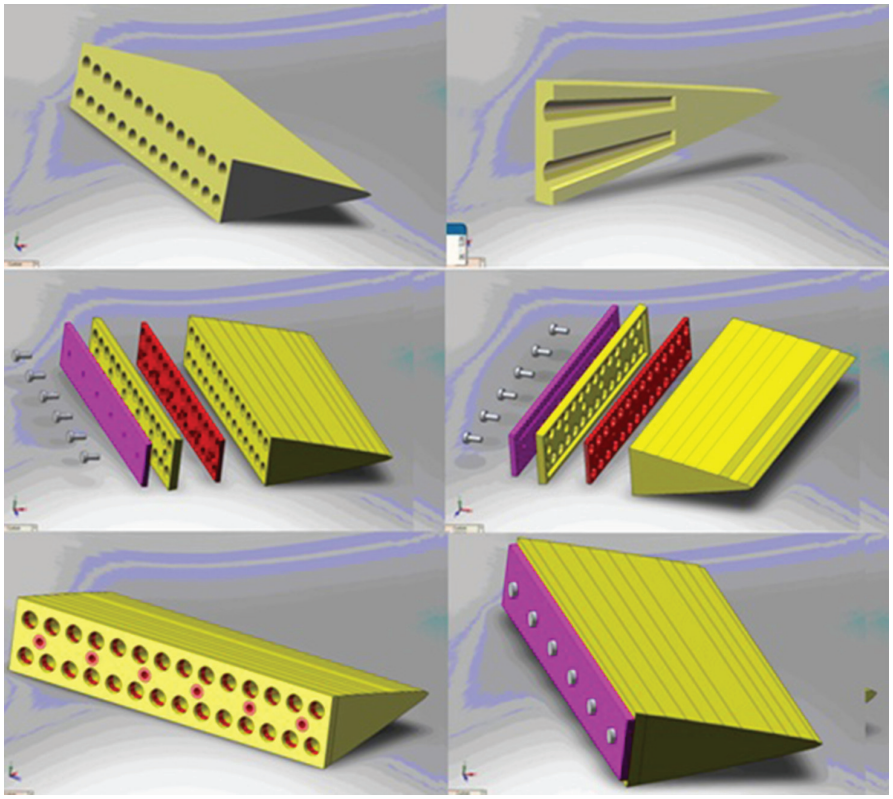
"Blade King" is led by LM Glasfiber, and is an extensive collaboration between LM Glasfiber and other companies, Risø and other research groups.

The first blades produced with the new technology are expected to be ready for the market by 2015.

Controllable rubber trailing edge flap

Numerical studies have shown a big potential for reduction of unsteady aerodynamic loads using a controllable trailing edge flap. The studies indicate that much faster control can be obtained with flaps compared with normal pitch of the whole blade as the mass of the flap can be made substantially lower than the blade. The big challenge is, however, how to obtain the flapping mechanism.

Risø has developed a controllable rubber trailing edge flap (CRTEF) which can be deflected by controlling the pressure in suitable designed voids within the elastic flap. A prototype flap manufactured in silicone rubber has a number of conical reinforced voids in chord wise direction. Static and dynamic test of the flap in a test rig has been performed. If wind tunnel test results confirm the predicted performance, the next step will be implementation of the flap on a turbine operating in free wind.



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Upper left shows a prototype, upper right shows a section view in the prototype.

In the middle is shown exploded views from two different angles.

In the bottom is shown the partly assembled trailing edge (left) and the total assembly (right).

May 7
Risø initiates the innovation network "3 x 8". Eight scientists, eight designers and eight business developers are going to develop ideas for at least one new high-technology company.

June 4
Risø celebrates its 50th anniversary. Popular lectures are transmitted live from risoe.dtu.dk. "Energy for the future – with Risø from nuclear power to sustainable energy" is published.

Bioenergy – a precious, renewable energy source

Biomass is organic matter created through plant photosynthesis with the sun as energy source, i.e. all types of plant material, wood, manure, household waste etc. Plant biomass can be used both for food for humans and animals and for energy in the form of heat, electricity and liquid fuel. Energy production based on biomass can offer significant environmental benefits in the form of reduced greenhouse gas emissions, particularly CO_2, and it can contribute to enhanced security of supply.

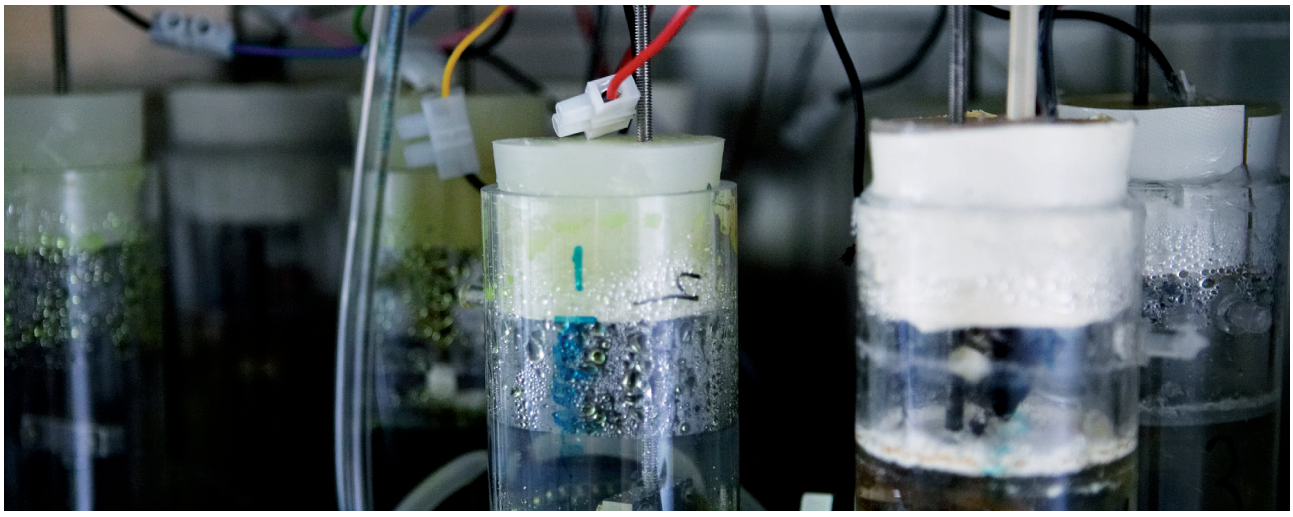
Risø conducts research into technologies for converting biomass into bioenergy and biomaterials.

Biomass resources and production of biofuels

By using the available Danish databases and green accounting, it is shown that agriculture, forestry and related industries may deliver up to 50% of the petrol consumption and up to 9% of the diesel consumption in Denmark year 2020 without any detriment to the current food production (including fodder production).

The calculations are based on second generation technologies.

Biomass resources for biofuels should however be utilized wisely taking into account the natural environment, diversity, and soil fertility in the longer term. At the same time, the agriculture and forestry sector should increase its focus on the other functions of plants such as groundwater protection, biodiversity and impact on soil fertility, including carbon storage in the future. In addition, there are a number of resources that are currently considered waste, but in the future should be valued higher.



Power from wastewater and residual products: It almost sounds too good to be true – power generation by microbial fuel cells utilising wastewater and residual products from the pretreatment of straw! But that is precisely the object of a new project launched by the Biosystems Division and the Fuel Cells and Solid State Chemistry Division at Risø.

June 13

Risø holds an Innovation Day for Region Sealand's businesses. The aims are to make Sealand's businesses think innovative hoping to create more growth businesses in the region and furthermore support existing businesses.

June 14

Risø DTU participates in Expo 2008 in Zaragoza in Spain. The Danish contribution is called Circulos de agua and is an exhibition of technologies and values from Denmark that have the potential to create global change.

Production of bio-oil and long-term storage of carbon
Bio-oil can be produced from straw and at the same time the coke residual product, biochar, can help capturing carbon dioxide from the atmosphere. The process, developed by DTU Chemical Engineering, takes place in a 'pyrolysis reactor' where comminuted straw is heated to about 500 degrees without oxygen (pyrolysis process) and bio-oil is formed, together with pyrolysis gas and biochar. The bio-oil can be used at power plants for instance, the pyrolysis gas can be used internally to run the process, and biochar can be used as a fertilizer and simultaneously mitigate climate change through carbon storage.

The task of Risø is to examine the degradability of biochar in soil and its impact on a number of microbial soil processes, including greenhouse gas emissions. Biochar is very slowly degradable.

So by converting straw to slowly degradable biochar we capture the carbon that was originally built into the wheat via photosynthesis and store it for centuries in the soil. That is why the biochar 'technology' is called 'carbon negative'. The carbon is actually removed from the atmosphere.

Apart from carbon storage, several studies have demonstrated that biochar has soil improvement properties. The large surface area makes biochar capable of preserving nutrients in the soil. Experiments have shown that the amount of added nutrients (fertilisers) can be reduced in sandy soils containing biochar.

The first short-term studies conducted in laboratory scale at Risø points to a loss of carbon around 5-15% of newly produced coke / charcoal within the first weeks, after which the soil respiration drops to the level of the soil without added material.

Incubation tests are performed with injection of 13C labeled coke/charcoal to be able to quantify the dynamic microbial processes in soil.

Demonstration plant of two-stage thermal gasifier "Viking"
Thermal gasification is a very efficient technique for converting biomass (especially woody biomass) into heat and power. The so-called "Viking" gasifier has now been scaled up to 750kW in cooperation with the company Weiss A/S in Hadsund. A new steam-dryer has been developed and functions very satisfactorily. This gives new opportunities for drying biomass at low energy consumption. Based on the results of the 750kW plant the next step is a 1.8MW plant.

Second generation biofuels can be used in the transport sector to cut down the CO_2 emissions from transport. Ordinary cars with a combustion engine run on up to 85% biofuels without problems. Biofuelled cars might therefore be one of the first steps toward a transport sector with less CO_2 emissions than today. Risø does research in second generation biofuels and has a strong expertise in "opening up" the plant waste material before it can be fermented to bioethanol.

June 24
DTU etablishes a climate centre at Risø DTU. The DTU Climate Centre shall ensure scientifically based advises on major challenges related to climate change.

June 29
Risø demonstrates polymer solar cells at the Roskilde Festival. 1,000 cells are handed out to the guests, - some of the cells are sewn into sunhats and connected to a small rechargeable battery po-wering a small radio.

Solar energy – by far the most abundant source of energy

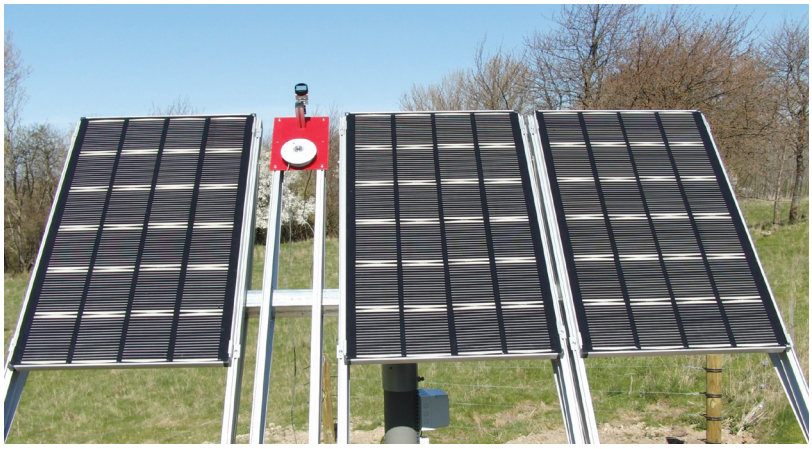
Solar energy technologies directly convert sunlight into electricity and heat, or power chemical reactions that convert simple molecules into synthetic chemicals and fuels. A sustainable society will need to rely on solar energy as one of its major energy sources.

Risø carries out research on future generations of photovoltaic technologies (PV) and in particular polymer solar cells – a technology that potentially may become tomorrow's ultra low-cost solar cells.

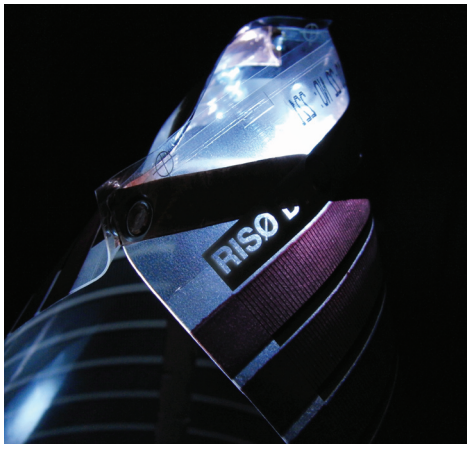
Polymer solar cells

Since the initial large scale demonstration of polymer solar cells Risø's research and development aims at simultaneously improving the durability, efficiency and production methods of polymer solar cells. New materials that absorb a larger part of the solar spectrum have been developed in order to convert more solar energy into electric power. Materials that facilitate the printing and coating processes needed for the production of flexible polymer solar cells has been developed. Such materials also improve solar cell stability after post treatment of the cells. Thorough lifetime testing and study of degradation mechanism is a key requisite for advancing durability.

Risø creates knowhow and facilities to fabricate flexible solar cells. Polymer solar cell modules were demonstrated at the 2008 Roskilde Festival, where Risø provided solar hats with radios powered by plastic solar cells. More than 2000 modules were fabricated in collaboration with industry. Since this initial large scale demonstration, processing through roll-to-roll coating has been developed. No vacuum steps are required and the all-printed process technology allows for much faster fabrication of solar cell modules. Power conversion efficiencies up to 2.3% opens for innovative applications and a number of demonstrations are being developed in close collaboration with industry partners.



In April 2009 Risø demonstrated the world first grid connected polymer solar cells.



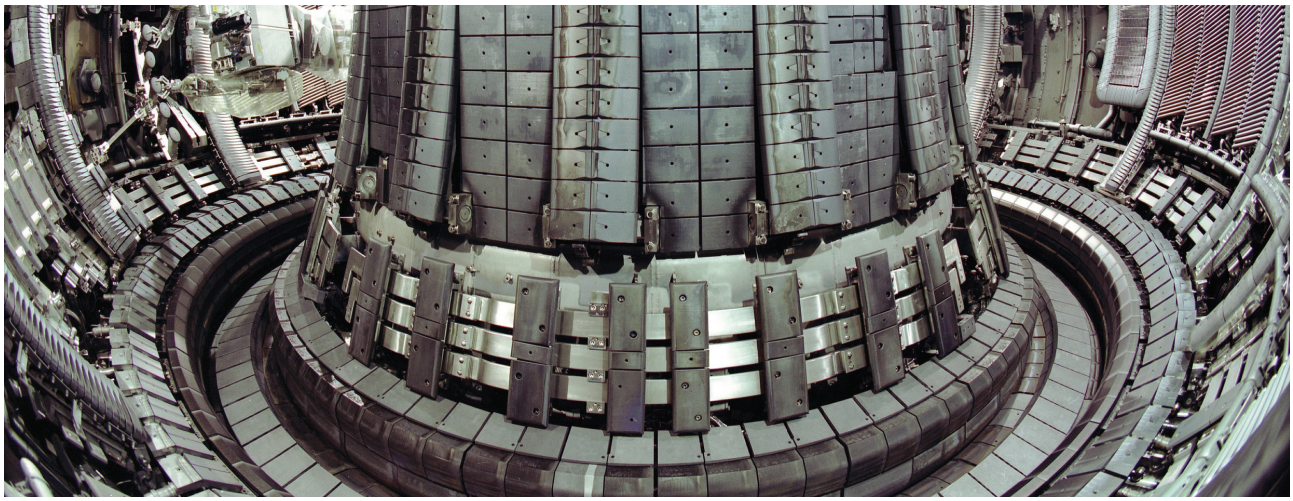
Risø is involved in demonstrating polymer solar cells as a means for powering LED based light products for developing markets.

July 4

Research Professor Mogens Mogensen is been honored with Christian Friedrich Schoenbeins Medal of Honor in recognition of his outstanding contribution to research and development of fuel cells.

July 11

UN Secretary-General gives the UN21 Award for 2007 to the India Solar Home Systems Project, which is based in UNEP Risø Centre. The project has created a new business model for financing domestic renewable energy including solar water heating systems.



Fusion energy – tomorrow's inexhaustible energy source

Fusion energy, which powers our sun and the stars, is released when light elements as for example deuterium and tritium fuse together. Worldwide coordinated fusion research started in the late 1950s to find ways to use fusion as an energy source here on Earth.

Risø has participated in fusion research since its very beginning, and the effort is an integrated part of the European program, through Euratom. This includes participation in the European fusion experiments, as e.g. JET (Joint European Torus) and contributions to the ITER project. ITER is a large-scale international scientific experiment that aims to demonstrate that it is possible to produce surplus of energy from fusion. From 50 MW of input power, the ITER machine is designed to produce 500 MW of fusion power - the first of all fusion experiments to produce net energy.

Fusion plasma diagnostics

How do fast ions, which result from fusion reactions, behave in the fusion plasma? This may be observed with high frequency microwave diagnostics (CTS - Collective Thomson Scattering). Extremely powerful microwaves are injected into the plasma and scattered by the wave fields that the fast ions leave in the plasma.

CTS is a relatively new measurement technique for measuring fast ions in fusion plasmas and is now part of the ITER baseline design. Since 2001, the development of CTS have been managed and operated by the fusion research group at Risø, which has now supplied the design proposal of the CTS system for ITER.

Turbulent transport of particles, energy and momentum

Turbulence is the main mechanism for transport across the confining magnetic field, and is a major focus area in the Euratom cooperation. Risø has developed several models and codes, which are important tools to investigate the properties of the turbulent transport of particles, energy and momentum in the edge of a magnetic confined fusion plasma.

In particular, the results and predictions from the ESEL code (Edge Scrape-off-layer Electrostatic) are in good agreement with experimental observations, and this code has now been "exported" to several European fusion laboratories.

Risø has presently the leadership of the JET task force on transport.

Fusion industry network

A network of Danish industrial partners, having interests in participating in the development of the fusion technology for ITER, has been set up and organized by Risø. It presently contains around 50 high tech companies. The purpose is to assist the companies in obtaining relevant competencies and building national and international networks in order to prepare for bidding on contracts on building up ITER.

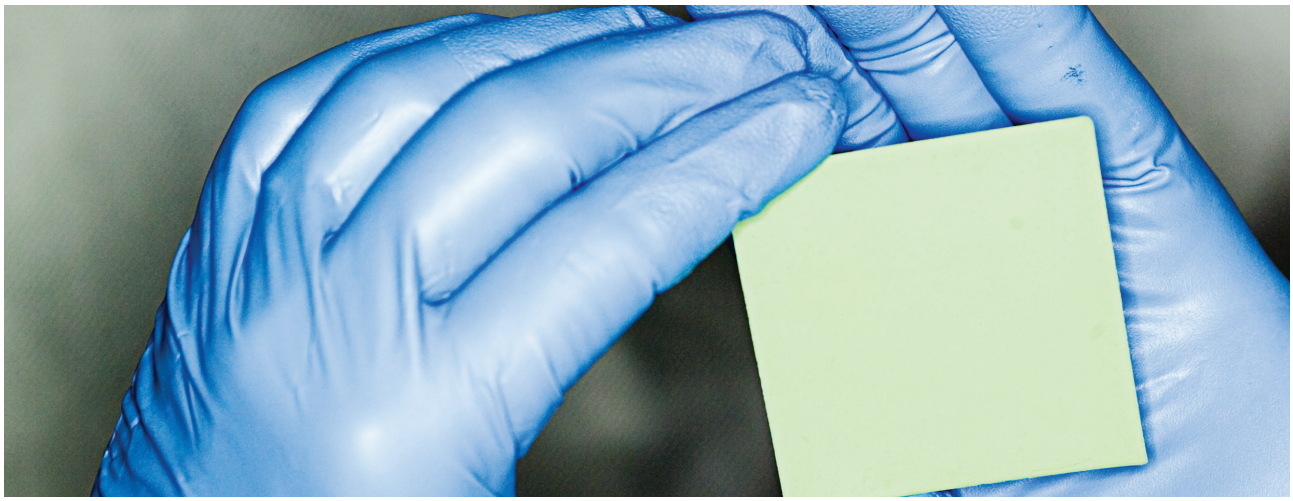
Fusion & Plasma Road Show

Risø has developed a Fusion and Plasma Roadshow. It is a science stage show with an exciting and easy to understand lecture and additional entertaining and illustrative experiments that introduces the audience to the world fusion and plasma research. This Road Show has been very successful with several appearances at high schools and for the general public in Denmark as well as at La Ville Européenne des Sciences in Grand Palais, Paris in November 2008.

The Fusion & Plasma Road Show under performance..

August 1
Lars Martiny is appointed head of the Radiation Research Division at Risø..

August 25
Head of Division Søren Linderoth is awarded the "AEG Elektronfondens Elektronpris" for his major contribution to the development of ceramic fuel cells.



Fuel cells & hydrogen – part of the flexible and efficient energy system

With fuel cells capable of producing electricity from fuels and fuels from electricity, we have taken a major step forward towards the flexible and efficient energy system. This will have a positive effect on the global environment because it contributes to efficient use of resources and facilitates integration of more renewable energy production.

Risø's research into fuel cells and hydrogen contributes to this development. Among other things, we are supplying the basic knowledge for Denmark's production of SOFC fuel cells.

Solid oxide electrolysis cells

In a society based mainly on renewable energy, storage and transport of this energy from the point of production to the point of consumption will play an important role. The main reason for this is that wind and solar energy production cannot be turned on and off at will. It is necessary to convert surplus electricity from e.g. wind power to chemical energy in the form of compounds such as hydrogen, methane or methanol. In this form the energy is easy to store and use in for instance vehicles.

A fuel cell converts chemical energy to electricity with high efficiency, but it is also possible to reverse the cell process to make it work as an electrolyzer, using electricity and water to make hydrogen and oxygen. There is considerable perspective in this because there are times when the production of electricity is greater than what can easily be consumed.

High temperature electrolysis appears to have the potential of becoming a viable economic solution to the production of hydrogen and synthesis gas, a mixture of hydrogen and carbon monoxide (CO), which can easily be transformed into synthetic fuels, such as synthetic natural gas or petrol.

That is why Risø has initiated a comprehensive development project in cooperation with a major foreign company to develop high temperature electrolysis. The project focuses on durability and performance of solid oxide electrolysis cells (SOEC), developed from solid oxide fuel cells (SOFC).

The high potential of the cells has already been demonstrated in preliminary tests.

Model of a fuel cell stack.

September 1

Risø welcomes 25 students to the new MSc programme in sustainable energy. The education opens up various and different job opportunities within industry, government and research.

September 1

29th Risø International Symposum on Materials is held 1 - 5 September. The theme is "Energy materials - Advances in characterisation, modelling and application".

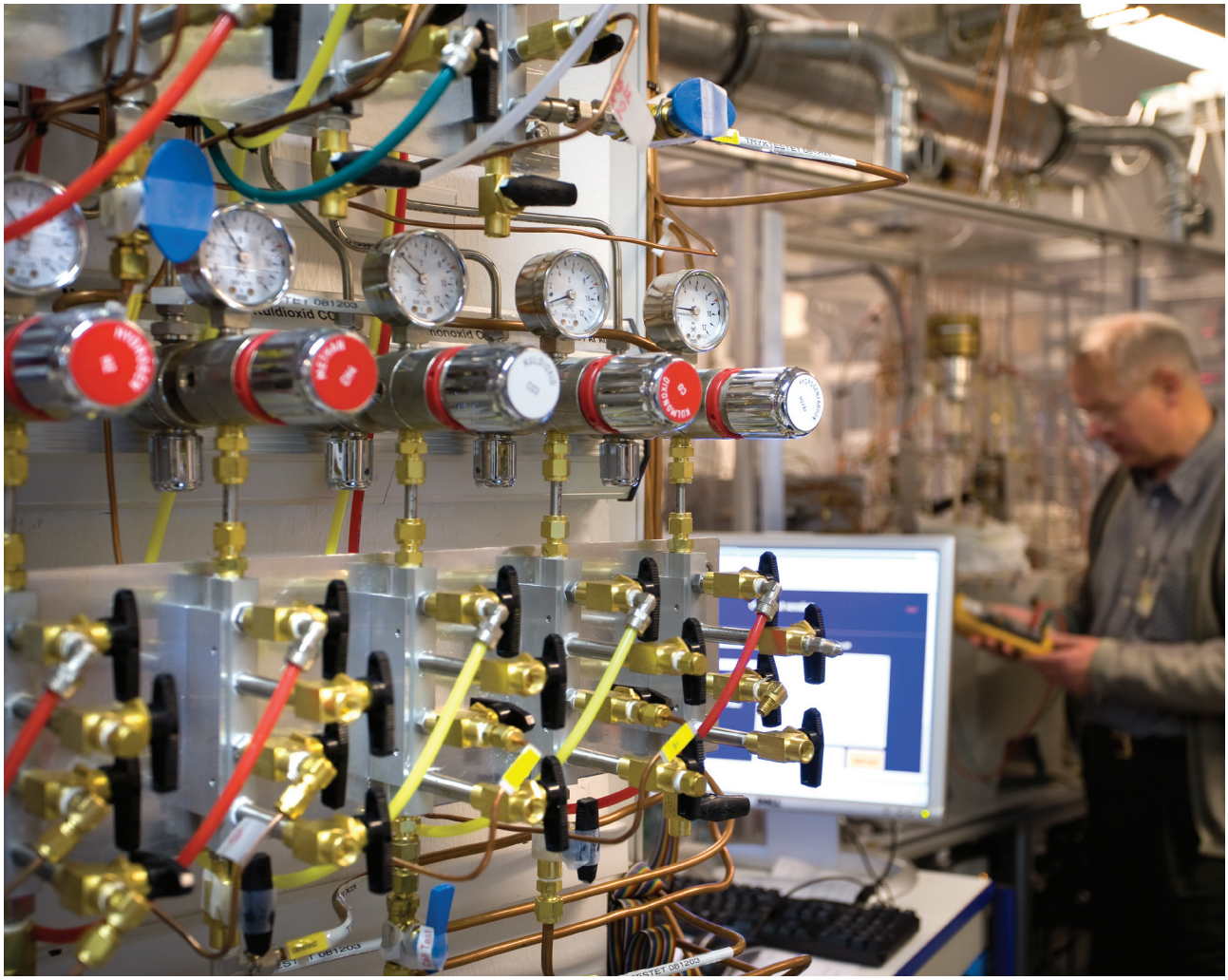
Third generation solid oxide fuel cells
Risø has succeeded in making the first ceramic fuel cells where the structural layer is metal rather than ceramic. This is essential to bring down the price and reach a large market.

The socalled 3G SOFC fuels cells have been tested and they look promising. However, there are still substantial challenges in developing the production methods and improving the durability. The 3G cells will be further developed, not the least in a project with Topsoe Fuel Cell as partner. This project includes development of an APU (auxiliary power unit) for use in trucks.

Electrochemical gas purification
There is an increasing focus on reducing exhaust emissions. Known solutions exist for cleaning the exhaust gasses from most stationary systems and from ordinary internal combustion engines (Otto engines). However, there are still unsolved problems in connection with Diesel engines and lean-burn engines (Otto engines where a surplus of air is used during combustion), especially with regard to the burning of soot (in the case of Diesel) and removal of NO_X (both Diesel and lean-burn).

Electrochemical cells of the solid oxide type can be used to clean flue gasses (exhaust gasses) of particles (soot) and nitrogen oxides (NO_X). Risø's work on electrochemical gas purification is focused on developing electrodes which are active for the oxidation of soot and active/selective for the reduction of NO_X in an oxidating atmosphere.

The Danish company Dinex Emission Technology A/S is a partner in a project on development of new and better electrode materials, modeling and manufacturing of prototype filter units and the testing of filters under realistic conditions.



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September 1
Risø is hosting the 13th EU-US Transport Task Force workshop held 1 – 4 September in Copenhagen and also the first meeting in EFDA's (European Fusion Development Agreement) topical group om transport in magnetized plasmas.

September 3
Sony Studios, Washington, USA, are doing shots at Risø for use on Jeopardy, one of the USAs most popular quiz shows running over the network as contests for school classes, university students and others

Energy systems – sustainable and reliable global energy supply

Globally, three central challenges for the energy systems of the future are emerging:

- They must strengthen the security of supply – also in the developing countries.
- They must ensure reduced emissions of greenhouse gasses so that we can halt climate change.
- They must contribute to fighting poverty by delivering reliable and affordable energy.

Risø contributes to solving these challenges by conducting research into energy policies and energy systems with particular focus on environmental and climatic consequences. And we contribute to developing and implementing new and efficient methods to strengthen the energy supply to poor areas in the developing countries.

SYSLAB - Research facility for intelligent energy systems

Market liberalization and increasing amounts of grid-connected renewable generation are the driving forces towards fundamental changes to the structure of the electrical power system. Present-day power grids – and the technology to control them – have never been designed to accommodate large numbers of small, distributed generators or fluctuating power sources.

SYSLAB is Risø's laboratory for intelligent distributed power systems. It is an experimental centre linking research, innovation and demonstration.

SYSLAB tests the possibilities for integrating a number of decentralized production and consumption components. Risø focuses on research in and analysis of intelligent energy systems and opportunities to support increased integration of wind power and other fluctuating energy sources into the energy grid.

SYSLAB is based on an electrical microgrid that includes wind turbines, PV plant and an intelligent office building, and it has a very flexible control setup. This flexibility is used to investigate the design of a software platform for distributed systems that enables activation of small energy resources so that they can participate in the control of the system.

Integration of wind energy in Europe

Integration of wind energy offers a number of technical challenges and challenges to the electricity market, and Risø examines these challenges on many fronts.

The Wilmar Planning Tool model is particularly suitable for studies of power systems with a high proportion of wind power because it involves partial predictability of wind power in the assessments. It is presently used as the basic model for wind integration studies in the European

Integration of wind energy offers a number of technical challenges and challenges to the electricity market, and Risø examines these challenges on many fronts.

September 3

500 climate experts meet from 3 to 5 September in Senegal for the first regional African Carbon Forum which also serves as a new marketplace for CO_2 trade. The UNEP Risoe Centre is one of the main organizers together with World Bank, UNDP, business organizations and the host government.

September 14

Risø's polymer solar cells are demonstrated at an exhibition in Saint James's Park i London.

Wind Integration Study (EWIS) performed by the European transmission systems operators (TSO). The All-Island grid study investigating wind integration in Ireland and Northern Ireland in 2007, and an ongoing wind integration study of the Eastern part of the U.S. power system performed for National Renewable Energy Laboratory in the U.S., also used/uses the Wilmar Planning tool.

Wilmar is developed in an international consortium with Risø and Stuttgart University as the main forces.

Future low carbon energy systems

In 2002 Risø established Risø Energy Report Series. The yearly reports deal with global, regional and national perspectives on current and future energy issues. Each report is based on internationally recognised scientific material and is fully referenced. Furthermore it is refereed by an independent panel of international experts. The target group is colleagues, collaborating partners, customers, funding organisations, the Danish ministries and agencies as well as international organisations such as the EU, the IEA and the UN.

The Risø Energy Report 7, published in 2008, was on "Future low carbon energy systems". It takes as its point of reference the recommendations of the Intergovernmental Panel on Climate Change (IPCC) in 2007 and presents state of the art and development perspectives for energy supply technologies, new energy systems, end-use energy efficiency improvements and new policy measures. It also includes estimates of the CO_2 reduction potentials for different technologies. The technologies are characterized with regard to their ability to contribute either to ensuring a peak in CO_2 emissions within 10 – 15 years, or to long-term CO_2 reductions.

Also, the report outlines the current and likely future composition of energy systems in Denmark, and examines three groups of countries: i) Europe and the other OECD member nations; ii) large and rapidly growing developing economies, notably India and China; iii) typical least developed countries, such as many African nations. The report emphasises how future energy developments and systems might be composed in these three country groupings, and to what extent the different technologies might contribute.

Risø Energy Report 7 was presented as introduction to the Workshop on Future Energy Systems, 19 – 20 November, - a DTU Climate Workshop.

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September 18

The Hevesy Laboratory steps in when the delivery of radioactive isotopes for Danish hospitals fails. The laboratory is able to provide Danish university hospitals with an alternative to cancelling vital bone scans.

October 1

LM Glasfiber establishes an office at Risø to strengthen cooperation with researchers at Risø. The objective is to develop blades and methods of production thereby making wind energy more competitive.

Climate change – the great challenge

Research based understanding of the interaction between climate change, eco-systems and socio-economic systems is pursued in Risø's climate programmes. They form the basis for advice on policy and strategic planning in both public and private sectors.

DTU Climate Centre at Risø DTU

2008 saw the start up of DTU Climate Centre with the central unit at Risø. The centre shall ensure scientifically based advises and research on major challenges related to climate change.

The centre will work with Danish public authorities, commercial organisations, industry and international organisations on consultancy and research aimed at developing and implementing climate change action plans in Denmark, the EU and developing countries. The strategic goals comprise technological and social aspects of modeling and assessment of climate impacts, vulnerabilities, adaptation strategies and mitigation efforts at national and international level.

Being localized at Risø within the Systems Analysis Division, the climate centre can utilise the synergy with the UNEP Risø Centre and the division's programme for energy systems analysis. The centre also works with other groups at Risø and staff from several departments at DTU.

The UNEP Risø Centre

The UNEP Risoe Centre on Energy, Climate and Sustainable Development (URC) supports the United Nations Environment Programme (UNEP) in its aim to incorporate environmental aspects into energy planning and policy worldwide, with a special emphasis to assist developing countries.

The UNEP Risoe Centre focuses on integrating such issues into national planning and policy worldwide, as well as supporting international activities related to global and regional environmental agreements, such as the UN Framework Convention on Climate Change (UNFCCC).

In 2008 the UNEP Risø Centre started a number of new activities within the climate area. A major program for support to adaptation activities in 15 African countries – CC DARE – was initiated with UNEP, UNDP and the UNEP-DHI Centre for Water and Environment in Denmark. For Danida the URC initiated clean development mechanism (CDM) support to five African countries as part of a so-called Green Facility aimed to provide opportunity for African countries to benefit from the global carbon market.

Finally the Centre jointly with UNEP was engaged by the EU Commission to support the EU Africa energy partnership over the coming years by engaging local experts in providing technical analysis and facilitating policy dialogue.

GNESD is a UNEP facilitated knowledge network of developing world Centers of Excellence and network partners. The main objective of GNESD is to carry out policy analysis on thematic energy issues which can facilitate in reaching the Millennium Development Goals (MDG).

October 27

Together with nine other leading European national laboratories Risø signs a Declaration of Intent to found a European Energy Research Alliance (EERA). The objective is to accelerate the development of new low carbon technologies.

November 10

On 10 – 12 November, Risø and Kathmandu Power and Energy Group brings together experts in Nepal from all parts of the world to discuss materials for wind turbines in poor and isolated rural areas.

Global Network on Energy for Sustainable Development (GNESD)
GNESD is a UNEP facilitated knowledge network of developing world Centers of Excellence and network partners. The main objective of GNESD is to carry out policy analysis on thematic energy issues which can facilitate in reaching the Millennium Development Goals (MDG).

The GNESD Secretariat is co-located with the UNEP Risø Centre. The secretariat facilitates the work of the Centers through research inputs, coordination, dissemination and administration, thereby making it easier for each Member Center to provide environmentally sound and propoor energy policy advice supporting sustainable development.

Risø Environmental Risk Assessment Facility
Risø Environmental Risk Assessment Facility (RERAF) is a unique plant growth facility belonging to a new generation of phytotrons. It comprises a row of physically and electronically separated environmental chambers with separate top and root compartments. Environmental risk assessment experiments can be carried out under fully controlled conditions. Plant and microbial populations, communities, and model ecosystems can be studied under climate conditions ranging from subarctic to tropical. In addition, RERAF constitutes a completely closed exposure and environmental risk assessment facility, where experiments with toxic substances, radioisotopes, gaseous air pollutants, trace elements, plant nutrients, transgenic organisms and climate change problems can be performed without risk to the environment.

A long-term (2-3 years) climate experiment, that examines the impact of future climate (the climate in 2075) on crop plants and plants from natural ecosystems over several generations, was launched in 2007. The experiment is designed so that other researchers have the opportunity to participate with their own experiments in the climate set-up. The changes in climate are expected to alter the selective forces experienced by populations in all ecosystems, including agro-ecosystems. Therefore, the effects of increased carbon dioxide, higher temperatures (+ 5 C), elevated ozone and two multi-factorial combinations on the population structure of barley and oilseed rape is investigated. After three generations of selection of seven genotypes of each species, the general trend is that the seed yield is lowered substantially by elevated temperature and increased by elevated carbondioxide. In the combined treatments where more climate factors were elevated, the production decreased. The observed climate effects might have serious consequences for our future agricultural production unless mitigating actions are evoked.

RERAF is in the period 2009-2013 part of a European infrastructure project with expected activities of foreign researchers in the facility.

Methane emissions from plants
In 2006 it was reported internationally that plants aerobically can produce and distribute methane to the atmosphere. Methane is a greenhouse gas 25 times stronger than carbon dioxide and this newly discovered methane source could represent 10-40% of all previously known sources of atmospheric methane.

A group of researchers at Risø has studied this mechanism, and they have been able - as the first independent group - to confirm methane release from plants and to demonstrate that pectin is the most likely source. The emission of methane is influenced by temperature and UV radiation and these environmental factors relate to different properties of the vegetation, the standing green biomass and the projected leaf and fruit surface area, respectively.

This new knowledge is an essential foundation for understanding the atmospheric greenhouse gas balances and for implementing mechanisms for remediation.

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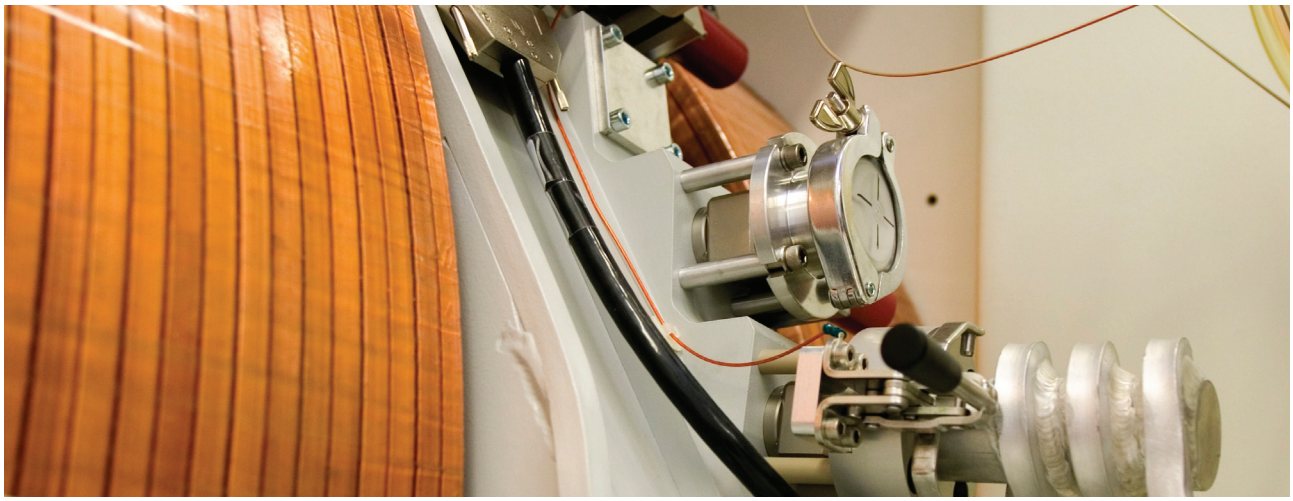
November 14
Risø's Fusion & Plasma Road Show is presented in La Ville Européenne des Sciences in the centre of the Grand Palais in Paris.

November 18
Head of Programme Peter Sommer-Larsen is the first to receive the Elastyren prize from the Danish Academy of Technical Sciences. The prize is awarded for his outstanding contribution to research into artificial muscles made of rubber.



Nuclear technologies – for health, environment and safety

Coming from a historical background within research for the peaceful exploitation of nuclear energy, Risø continues to contribute with research in nuclear technologies.

Today, focus is on the measurement of radiation dose, in the efficient detection and analysis of radioactive isotopes in environmental samples and on the application of isotopes and nuclear technologies in medical sciences. In addition, Risø plays a significant role in the national nuclear preparedness programme and radioprotection surveillance.

OSL for surface dating on Mars

Risø investigates the thermoluminescence (TL) and optically stimulated luminescence (OSL) properties of a variety of natural and synthetic materials suitable for use in personal and environmental dosimetry. Special emphasis has been put into the development of OSL techniques using natural materials and ceramics in retrospective accident dosimetry and in archaeological and geological dating.

Now Risø is also engaging in Mars research to find out if OSL can be used for dating of surface sediments on Mars and through that give insight into climate changes. An international space research project has been initiated with the aims to develop a prototype of a measuring instrument which can be used for dating the sediments.

Mars is a dynamic planet, and a determination of when the surface of Mars has been affected by for instance wind or water flows, is crucial to our understanding of past climate changes on Mars.

The instrument, developed in the project, is a miniature version of the Risø TL/OSL reader. Besides the major requirements for volume and weight of the instrument, the instruments must also be able to operate in a vacuum and under large temperature variations. The research is funded by the European Space Agency and runs over a two year period.

Radioactive tracer to diagnose Alzheimer

The Hevesy Laboratory at Risø houses a cyclotron for the production of isotopes. The laboratory produces isotopes and radioactive tracers for research and medical purposes and conducts research in the development of new radioactive pharmaceuticals. The research focuses in particular on the development of new isotopes, radiochemistry and radiopharmacy.

The Hevesy Laboratory has joined GE Healthcare in the development of a radioactive tracer that may help in an early diagnosis of Alzheimer's disease. GE Helthcare is working to develop a radioactive tracer that can visualize the amount of amyloid protein in the brain, an indicator of the progression of Alzheimer's. The cooperation between GE Healthcare and Risø may help to facilitate an earlier medi-

Risø has developed OSL techniques using natural materials and ceramics in retrospective accident dosimetry and in archaeological and geological dating. Risø's TL/OSL reader is sold to laboratories worldwide.

November 19

Risø Energy Report 7 "Future low carbon energy systems" is published and presented as an introduction to the DTU Workshop on Future Energy Systems, 19 - 20 November.

November 23

The 14th International Symposium for the Advancement of Boundary Layer Remote Sensing, ISARS 2008, is held at Risø DTU, chaired by Risø.

cal treatment of the disease, which now has affected over 65,000 people in Denmark alone, a figure that is expected to quadruple by 2050.

Late 2008 the first batch of the drug was released from the Hevesy Laboratory for clinical trials at the Danish hospital Rigshospitalet. It was the culmination of nearly 1½ years of work with the setup of the production, analysis, quality assurance, validation, training, and approval of the procedures.

The studies will show if uptake of the radioactive tracer indeed correlates with the formation of amyloid protein and on the development of Alzheimer's.

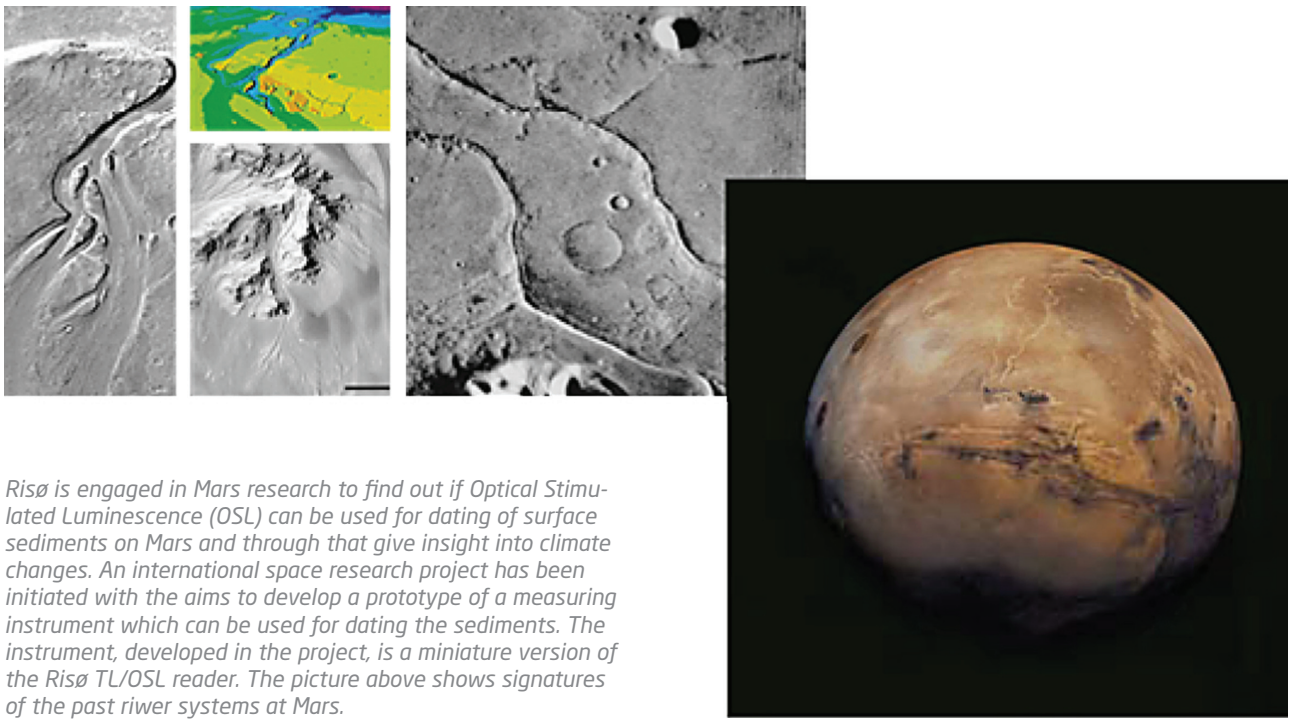
Long-lived radioactive isotopes in nature

At the culmination of a three-year project, Risø has developed new methods to examine how long-lived radioactive isotopes behave in nature. This is critical in order to better assess risks to and extent of potential human and animal exposure.

This project was focused on long-lived radioactive waste, including technetium-99, iodine-129 and plutonium isotopes, which may spread into the environment from nuclear facilities, storage of radioactive waste or accidents resulting in radioactive contaminations.

The results show that iodine-129 occurs in precipitation over Europe in small but significantly higher concentrations than in Asia, U.S. and Africa. This is due to release into the sea from the reprocessing of nuclear fuel at Sellafield and La Hague, as well as due to resuspension from the European coastal areas. The presence of technetium-99 and iodine-129 in seawater from the Baltic Sea also shows that contamination in the North Sea enters into the Baltic albeit in small quantities. In addition, the project has demonstrated that plutonium in dirt originating from Thule in Greenland only is transferred to vegetation to a very small extent.

The Hevesy Laboratory at Risø houses a cyclotron for the production of isotopes. The laboratory produces isotopes and radioactive tracers for research and medical purposes (e.g. for use in the hospital's PET scanners shown at the picture) and conducts research in the development of new radioactive pharmaceuticals.



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November 25

The new Experimental Research Facility for Blade Structure is inaugurated. There is room for a 30-40m wind turbine blade in the big hall.

December 9

IPCC invites John M. Christensen, UNEP Risø Centre, and Peter Hjuler Jensen, Risø's Wind Energy Division, to be one of the lead authors for the IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation. They are the only Danish lead authors.

Education and training

Risø is deeply involved in education and training, and both university students and participants in Risø's commercial courses come from all over the world, demanding a high level of quality.

Master of Science in Engineering (Sustainable Energy)
In the coming decades the energy systems throughout the world will undergo major changes and crucial issues will be environmental, economic and social sustainability.

In 2008 DTU launched a MSc program in Sustainable Energy. The education is offered by Risø DTU in cooperation with a number of departments at DTU, and 1 September a team of 23 students started their studies at Risø.

The aim is to educate experts in various energy technologies and energy systems with the focus on sustainability. The education opens up various and different job opportunities within industry, government and research. Professional tasks could be implementation of sustainable energy technologies into existing or new energy systems including modeling and evaluation of impact on eco-systems and society.

Training courses
Risø has continued to offer courses in WAsP Engineering, i.e. the Risø computer program for the estimation of extreme wind speeds, wind shears, wind profiles and turbulence in complex terrain, and in WAsP, the Wind Atlas Analysis and Application Program developed by Risø.

Among Risø's commercial courses is also the course in "Validation and process control for electron beam sterilization". This course also contains lectures on effects of radiation on polymers and on biocompatibility.

A new generation of young people is about to mature along with the concept of sustainability. The first students at DTU´s new education in Sustainable Energy grapple with the challenge of our time and shed light on sustainable energy from a modern point of view.

A class of students from the new education in medicine and technology at DTU spent two afternoons with experiments at Risø. The laboratory experiments at Risø also involve technicians. "It is wonderful to work with the materials in practice", is a common remark from the students.

Innovation and business

Risø has a long track record of cooperation with industries, innovation activities and the supply of highly specialized products and services on commercial terms.

Through a dedicated innovation activity, Risø has created a systematic proces for the transformation of its knowledge into concrete business ideas:

- Building on our technological advancements, we identify and initiate business start-up's
- In collaboration with industrial partners we address and provide solutions to technological challenges that prevent the creation of new products
- We undertake specialized assignments on commercial conditions
- We provide specific products, where we have a special expertise.

Risø collaborates with several hundred companies a year. With more than 300 scientists with expertise from a broad range of technologies Risø is a valuable innovation partner. Our know-how can help create new products or optimize production in both newly established and existing businesses. Thereby industry can improve its potential for growth through collaboration with Risø.

Collaboration with Risø often begins with the joint identification of the technological problems that may be barriers to increased competitiveness. On the basis of its research-based know-how, Risø will identify the often interdisciplinary solutions for the benefit of the business enterprise.

Network to turn waste into gold - an example of Risø's innovation activities

Can waste turn into gold? Yes, perhaps, if you put different people together and make them think together. The waste that may be a problem to the companies, may be of high potential seen from the scientists' perspective. This is the philosophy behind the Risø initiative and why Risø in the autumn 2008 launched a new network that brings companies and scientists together focusing on biological waste.

The network on "Biological waste as a resource" was fully established at the end of 2008 and has members from the manufacturing industry and companies dealing with biological waste. Other members include consultants, trade organizations and researchers.

Early in the establishment phase, a number of emerging project ideas were tested in cooperations between some of the participating companies. Other ideas are now in the process of further development in collaborations involving companies as well as researchers and business developers from Risø.

Demonstration agreements on spinner anemometers

RIA (Risø Innovation Activities) and the Wind Energy Division at Risø has for some time been working at both the technical and commercial development of a new spinner anemometer. As a result of these efforts demonstration agreements were signed with two major international wind turbine manufacturers and more agreements are expected.

Prototypes of the new spinner anemometer is today installed at 4 turbines (two in Denmark and two abroad) and the data reported to Risø are promising. A good collaboration with the German company Metek that produces the prototypes has ensured a smooth development process.

The network on "Biological waste as a resource" visit the Asnæs power plant in Kalundborg.

Research facilities

Research and development in the energy sector includes a number of tasks that can only be achieved through the use of large international research facilities such as synchrotrons, reactors and fusion experiments. Risø has bilateral agreements on the institutional level and through a qualified staff access to and experience with such facilities in Europe and the USA, e.g. European Synchrotron Radiation Facility (ESRF), Paul Scherrer Institut (PSI) and Hamburger Synchrotronstrahlungslabor (HASYLAB).

Below is listed some of Risø's own research facilities.

Høvsøre Test Station for Large Turbines	Large mega-watt wind turbines are being tested, and research projects on boundary layer meteorology and modeling are conducted.
Experimental Research Facility for Blade Structure	Experimental research facility for full scale testing of blades. The building can hold a blade at the size of around 30-40 meters and combined loading can be applied.
SYSLAB A research facility for intelligent energy systems	Flexible platform for research in advanced control systems and concepts, power system communication and component technologies for distributed power systems.
RERAF Risø Environmental Risk Assessment Facility	Plant growth facility belonging to a new generation of phytotrons. Experiments can be carried out under fully controlled conditions.
Brandbjerg (CLIMAITE) Experimental research site to model the Danish ecosystem for the year 2075	Established by CLIMAITE, a Danish research centre to investigate how climatic changes will affect biological processes and natural ecosystems. Center leader: Risø.
MaxiFuel pilot plant	Co-production of bioethanol, biogas and hydrogen is being studied.
Pre-pilot plant for advanced ceramic process technology	Manufacturing technologies, characterization methods ands sintering furnaces. Is used for production of solid oxide fuel cells (SOFC) and electrochemical cells for electrolysis.
Facilities for electrochemical testing of fuel cells and electrolytic cells	Test stations for electrochemical testing for short-term, long-term and accelerated testing in controlled environments.
Laboratory for mechanical testing	Equipped for both uniaxial and multiaxial testing. Accredited by the Danish Accreditation DANAK.
Microscopes	Electron microscopes comprising different types of transmission, scanning and scanning probe microscopes.
Polymer solar cell processing facilities	Glove box process line for fabricating and testing laboratory scale solar cells in controlled atmosphere. Reel-to-Reel (R2R) coating, screen printing and lamination facilities for all-printed polymer solar cells.
X-ray scattering facility	In-situ studies of the structural changes that take place in advanced energy materials.
Thermometry laboratory	Accredited "in situ" measurements in the range -196 to 1600 K, especially demanding temperature measurements in large power plants and incinerators.
Hevesy Laboratory Radiochemical and radiopharmaceutical facility	Comprises a 16 MeV proton biomedical cyclotron with a beam-line for production of radioisotopes, and two clean rooms complete with hot-cells. Approved by authorities for the development and production of a portofolio of radiopharmaceuticals.

Mission:

Risø DTU contributes to research, development and international exploitation of sustainable energy technologies, and strengthens economic development in Denmark.

Vision:

Risø DTU is one of Europe's leading research laboratories in sustainable energy and is a significant player in nuclear technologies. Risø creates pioneering research results and contributes actively to their exploitation, both in close dialogue with the wider society.

Management

Director: Henrik Bindslev			
Head of Biosystems Division	Kim Pilegaard	Head of Radiation Research Division	Lars Martiny
Head of Fuel Cells & Solid State Chemistry Division	Søren Linderoth	Head of Solar Energy Programme	Peter Sommer-Larsen
Head of Materials Division	Dorte Juul Jensen	Head of Systems Analysis Division	Hans Larsen
Head of Plasma Physics and Technology Programme	Jens Juul Rasmussen	Head of Wind Energy Division	Peter Hauge Madsen
Head of Administration		Lisbeth Grønberg	
Head of Information Service		Birgit Pedersen	
Head of IT Service		Michael Rasmussen	

Personnel 2008 - FTE

Total number of employees - Full Time Equivalents	582
Of this	
Scientists (VIP)	236
Ph.d students	66
Other staff (TAP)	280

Additionally, a number of visiting scientists and master students.

Operating statements 2008 (DKK mill.)

Total income	586
Of this	
Basis appropriation	287
Programme activities	188
Market controlled activities	111
Total expenditure	596
Of this	
Salaries	290
Operating expenditures	276
Depreciation	30

www.risoe.dtu.dk

Risø DTU is the National Laboratory for Sustainable Energy. Our research focuses on development of energy technologies and systems with minimal effect on climate, and contributes to innovation, education and policy. Risø has large experimental facilities and interdisciplinary research environments, and includes the national centre for nuclear technologies.

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