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Larsen, Hans Hvidtfeldt; Olsson, C..

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Systems Analysis Department

Annual Report 2003

Edited by Hans Larsen, and Charlotte Olsson



This report describes the work of the Systems Analysis Department at Risø National Laboratory during 2003.

The department is undertaking research within Energy Systems Analysis, Energy, Environment and Development Planning – UNEP Risø Centre, Safety, Reliability and Human Factors, and Technology Scenarios.

The report includes summary statistics and lists of staff members.

Systems Analysis Department

Systems Analysis Department
Risø National Laboratory
P.O. Box 49
Frederiksborgvej 399
DK-4000 Roskilde

Available on request from Information
Service Department, Risø National Laboratory,
(Afdelingen for Informationservice,
Forskningscenter Risø)
P.O. Box 49

Systems Analysis Department Annual Report 2003

Edited by
Hans Larsen, and Charlotte Olsson

Communication consultant
Bryan Cleal, Risø

Risø National Laboratory
Roskilde · Denmark

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Introduction

The year 2003 was characterized by a high level of activity and by a strengthening of the international engagement, both through an increased volume of international research contracts, and through participation in international collaboration and new networks.

The year 2003 has been a challenging year for the department. Danish research funding has been reduced, especially with regard to energy research, but by the end of the year some recovery was observed, in particular for basic research funded through the research councils. In this environment the department has compensated for the more limited Danish funding with international involvement in major new projects, including several new EU-funded research projects.

Risø National Laboratory is devoting increased emphasis to research that supports sustainable development, which ensures economic development and meets concerns for the environment. The research includes energy technologies and policies for post-Kyoto goals that aim to reduce the environmental impacts of energy consumption. The department was, in this regard, strongly involved in editing the Risø Energy Report 2, on "New and emerging bioenergy technologies" and the planning and realisation of the Risø International Energy Conference, Energy Technologies for post Kyoto Targets in the Medium Term, which took place at Risø 19 – 21 May 2003.

Early in 2003 a collaboration agreement was signed with the Centre for Human-Information Interaction at the University of Washington, USA, as the basis for establishing the joint Cognitive Systems Engineering Centre with the objective to further effective and safe operation of socio-technical systems, user friendly and safe consumer products and contribute to teaching and education.

In May 2003 Force Technology and the Systems Analysis Department – Risø National Laboratory, signed a cooperation agreement that involves the establishment of a new centre within the area of human factors – the Danish Human Factors Centre. Research at the Centre will focus on all human factors in a control and operator environment affecting efficiency and safety levels.

By the end of 2002 it was agreed with the steering committee for The Global Network on Energy for Sustainable Development (GNESD), to locate a new secretariat

as a separate unit in the Systems Analysis Department. The secretariat was fully staffed early in 2003 and, by the end of the year, became fully operational.

The research activities in the Systems Analysis Department are undertaken within the following research programmes:

- Energy, Environment and Development Planning, UNEP Risø Centre, *John M. Christensen*
- Energy Systems Analysis, *Frits M. Andersen*
- Technology Scenarios, *Per D. Andersen*
- Safety, Reliability and Human Factors, *Nijs J. Duijm*

The department has appointed a number of Scientific Advisory Panels to strengthen the contacts and interactions with Danish and international scientific communities and end users of results, e.g. industry, governmental authorities, and international organisations. The Panels are asked to give strategic advice on the direction for future activities, as well as assess the quality and relevance of ongoing and proposed activities. Two of the panels met in the autumn and provided valuable input for the annual plan for 2004 and the upcoming strategy process.

In 2003, 70 per cent of the department's activities were financed through national and international research contracts, contracts with national agencies and international organisations, as well as contracts with industrial companies – especially in the energy sector. The remaining 30 per cent of the activities were financed by governmental appropriations. Although a decrease in funding from national research programmes has taken place, this has been fully compensated for by an increase in funding from international research programmes.

The total gross/net turnover of the department in 2003 amounted to approximately DKK 71,6 mill/ DKK 53,6 mill (EUR 9,6 mill/EUR 7,2 mill)

By the end of the year, the total number of employees in the department was 68. This included an academic staff of 63 – including, engineers, natural scientists, economists and social and behavioural scientists – of whom nine were PhD students working in co-operation with various universities in Denmark and abroad. There were four secretaries and one technical support staff. During 2003 two staff members earned a PhD degree.

Hans Larsen, Head of Department



Technology Scenarios



Per Dannemand
Andersen
Head of Research
Programme

The aim of the programme is to analyse commercial, societal and scientific possibilities/consequences in relation to the selection, development and commercial application of new technologies. The programme focuses on technology foresight and other methodologies for prioritising science and technology in domains such as new energy and environment technologies, plant biotechnology and emerging industrial technologies (i.e. nano technology).

Once again in 2003 the PhD course in Management of Research and Innovation was carried out in collaboration with Copenhagen Business School. The course has now been offered four times with approximately 50 participants, and it will be developed further in 2004.

One of the programme's scientific milestones in 2003 concerned finalising of the basic research project "Dynamic dialogue processes and controversial technologies", sponsored by the Carlsberg Foundation. In an age dominated by one singular mode of knowledge production, that of institutionalised science, planning processes do not always consider the needs of those affected by the solutions. The project raised the question of whether a new fourth age of risk concerns is commencing, in which risk assessors, policy-makers, and decision-takers have to rethink risk and apply interdisciplinary scientific advice in support of normative, holistic decisions pertaining to risk.

There have been three overlapping ages of risk concerns: a technical age, a human-error age, and a socio-technical age. Based on observed tendencies, especially in the domain of new biotechnologies, there is a need to develop new frameworks for risk decisions that supplement technical, operational, and organisational aspects, and which also address matters such as normative values, utility value, transparency, uncertainty, and precaution. To better understand and analyse risk as a holistic and interdisciplinary entity, we developed a theoretical frame including four theoretical fields – what we loosely define as the theoretical tetrahedron: technological risk assessment; technology foresight; systems thinking; and contemporary sociology of science.

Another scientific milestone in 2003 concerned the project "European Energy Delphi (EurEnDel). Technology and Social Visions for Europe's Energy Future". EurEnDel assessed long-term developments in energy technologies, their potentials and expected impacts. In 2003 the Technology Scenarios research programme was responsible for a EU-wide Delphi survey that covered the need for reliable information on long-term trends and developments. Two rounds of Internet based Delphi questionnaires were submitted to approximately 3000 experts. In

the first round, submitted in June and July, 679 energy experts from 48 countries participated. In the second round, submitted in August and September, 416 experts from 42 countries participated. The results of the Delphi survey and the project as a whole, can be downloaded from the project's homepage: www.izt.de/eurendel. The project was funded by EU's fifth framework programme. It was coordinated by IZT in Berlin.

In 2003 the Technology Scenarios research programme was very successful in attracting new projects. This includes both research and development oriented projects, as well as policy oriented technology foresight projects. Some of these are briefly presented in the following:

Nordic Hydrogen Energy Foresight

The Nordic H2 Energy Foresight is a joint research project involving 16 partner organisations, including R&D institutes, energy companies and industry, from the five Nordic countries – Denmark, Finland, Iceland, Norway and Sweden. The project has also included stakeholders from the two autonomous territories Greenland and the Faeroe Islands. It was launched in January 2003 and is expected to run until June 2005. The Nordic Hydrogen Energy Foresight has the following objectives:

- To develop socio-technical scenarios for a future hydrogen society and explore roadmaps to commercialisation of hydrogen production, transport, storage and utilisation
- To contribute as decision support for companies, research institutes and public authorities in order to prioritise R&D and to develop effective framework policies
- To maintain and develop scientific and industrial networks.

Participants at the Project kick-off meeting and scenario workshop in Reykjavik, Iceland.



The Nordic Hydrogen Energy Foresight project is supported by the Nordic Industrial Fund and the Nordic Energy research Programme.

Activities in 2003 comprised a scenario workshop, held in Reykjavik and a vision workshop held in Stockholm. Furthermore, a review of hydrogen and fuel cell related research and development activities in the Nordic countries was made, in addition to a number of comprehensive interviews with stakeholders in all five countries. At the scenarios workshop we discussed the external conditions around the future hydrogen society, concerning general issues that cannot be affected but which are likely to effect introduction of hydrogen energy in the Nordic energy systems.

The workshop produced three scenario sketches for the Nordic Energy introduction. The vision workshop brainstormed about visions for hydrogen technologies in the hydrogen society. In contrast to the scenario workshop, the vision workshop addressed issues that can be affected by policy, industry or science. Furthermore, ambitious targets for hydrogen's share of the total Nordic energy system for 2030 were set up. These varied over the scenarios from 6-7% in one scenario to 16-19% in another scenario. Further information can be downloaded from the projects' homepage: <http://www.h2foresight.info/>.

Regional Foresight – Ringkjøbing County H2 Energy Foresight

In spring 2003, Ringkjøbing County Council discussed and approved a vision. The vision was to establish and develop Ringkjøbing's status as a leading international player in the field of renewable energy technologies and especially hydrogen technologies. As the hydrogen economy is generally regarded as a longer-term goal, the time perspective of the regional foresight was 2030.

Risø National Laboratory was chosen as project consultant on the project. The process was based on involvement of a broad group of actors in the four working groups: 1) Regional production and consumption of energy, 2) stationary use of hydrogen and fuel cells, 3) use of hydrogen in the transport sector and business development perspectives in the sector. Two one-day meetings were held in each group. The whole project was inaugurated by a regional energy conference with more than 60 participants. The project resulted in five proposals for regional demonstration projects for hydrogen (or hydrogen /fuel cell) energy systems.

Furthermore the project resulted in recommendations on 1) utilisation of regional energy resources, 2) regional business development opportunities, and 3) suggestions

for national energy and innovations policies. For further information please visit <http://www.brintamt.dk/>.

Study of Strategy Processes in National Research Programmes

This project analyses the character of the changing identity and role of science, through a study of strategy and prioritisation processes in connection with national research programmes within the technological area. The two cases of the project are the strategy processes of The Danish Technical Research Council (STVF) and The Danish Energy Research Programme (EFP). The study builds on recent developments in the sociology of technology and science and on studies of research governance and policy. In addition the study draws on knowledge about tools for structuring strategy processes, e.g. scenario methods, technology foresight, and roadmapping. The study will strive to make recommendations on strategy processes in national research programmes. The Danish Social Science Research Council funds the project and it will be concluded in 2004.

Danish National Wind Energy R&D Strategy and Plan of Action

The programme was selected as a consultant by the Danish energy research authorities to carry out this strategy process. The first part of the strategy was initiated and finalised in 2003. The strategy paper can be downloaded from <http://www.energiforskning.dk/>.

Creative Industries Foresight

A foresight project on technologies for creative industries was initiated in 2003 and sponsored by the local organisation Musicon Valley (see www.musicon-valley.dk).

Nano Technology Foresight

In December 2003 the Danish Ministry of Science, Technology and Innovation launched a technology foresight project on nanoscience and nanotechnology. The programme won the invitation to tender, for process consultant on the project, together with staff from Risø's Polymer Department (see <http://www.teknologiskfremsyn.dk/>).

Green Technology Foresight

The Danish Environmental Agency has initiated a technology foresight project on design of environmentally sound products and materials. A project team with The Technical University of Denmark (project leader) and Risø National Laboratory has been selected to carry out the project. The project is running 2004-2005.

Safety, Reliability and Human Factors



Nijs Jan Duijm
Head of Research
Programme

The aim of the research programme, "Safety, Reliability and Human Factors", is to develop methods for analysing safety and reliability of complex technical systems, taking into account technical, organisational, and human factors.

The programme consists of a permanent staff of 14 people. In 2003, we were also host, for three months, to a guest researcher from Ufa State University, Russia, working on pipe-line safety and safety management. By the end of the year, we had three PhD students within the programme, two of them on a shared employment with Roskilde University Center. Moreover, a number of students, both international and Danish, joined us regularly through the course of the year.

One of our senior scientists was detached to the Fraunhofer Institute of Chemical Technology, Karlsruhe, Germany, for a period six months. During this time he worked on a joint project related to the development of fast-deploying emergency valves based on airbag-technology.

Research related to safety in medicine

One of the PhD projects that started this year aims at developing techniques to make real time electronic anaesthesia records, using voice recognition during operation, which would not distract the anaesthetist's attention from the patient. The PhD position is financed by means of the EU "ADVISES" network, and is undertaken in co-operation with Herlev hospital.

Another PhD project focuses on safety culture in hospitals in relation to patient safety. The aim of the project is to investigate what role reporting of human and organisational errors and incidents has for the safety culture and the general level of safety in an organisation, and to describe a framework for how reporting of errors and incidents may be integrated into organisational learning and safety management. The aim is to find "indicators", that can measure and predict the level of safety culture in a given organisation. A safety culture question-

Work on safety culture and reporting of incidents in Danish hospitals performed by Risø in the previous year resulted in a number of recommendations and requirements regarding a system for reporting incidents in the Danish health care system. These recommendations have been taken over and are integrated in the Act on Patient Safety in the Danish Health Care System, Act No. 429, that passed through the Danish parliament in 2003.

naire, which aims at providing feedback to staff to promote the development of awareness of patient safety culture, has been developed, tested and revised this year. The questionnaire can also be used to measure changes after interventions. Testing of the questionnaires and use of the results for guiding intervention has been done in collaboration with the regional health authorities of Frederiksborg and Copenhagen.

Reliability and renewable energy systems

In 2003 we concluded a study "Optimised and uniform safety and reliability of offshore wind turbines", funded by the Danish company Elkraft System, in the framework of the "PSO" research support agreement. Past experience suggested that the reliability of the control and safety system of wind turbines for electric power generation is too low compared to the reliability of the structure (the tower and blades). If it is possible to balance the failure probabilities of these two sources and if the total probability of failure is optimized, then the costs of the turbines can be reduced.

The project resulted in an approach to link and optimise the reliability of the control and safety system and structural reliability of wind turbines, in an analysis of the major wind turbine accidents in Denmark, and in exemplifying calculations to define more effective strategies for taking the reliability of the wind turbine to a desired level. It was demonstrated that improvement of the safety system has a larger effect than strengthening the structure.

Work continued on safety aspects of ammonia as a bridge fuel for fuel-cell powered vehicles in the EU project "ACCEPT", while we participate in a Network of Excellence on safety aspects of a hydrogen-based society, "HYSAFE", which was successfully submitted in 2003.

Safety and human factors in aviation

The programme has an established tradition of work within the aviation domain. There are currently two projects related to aviation. The project "Safesound" deals with the use of audible signals to enhance the pilots' situation awareness and reduce the workload. The other project "SEE" investigates the possibility to use infrared (IR) cameras to enhance pilots' vision in fog and in the dark in particular during take-off and landing.

"Safesound" looks at the possibility of using direct voice input (DVI), direct voice output (DVO) and 3D-sound in order to achieve the above-mentioned objectives. Last year Risø investigated pilots' tasks in a traditional airliner cockpit by recording and analyzing real flights as well as flights carried out in a simulator. Results from this activity

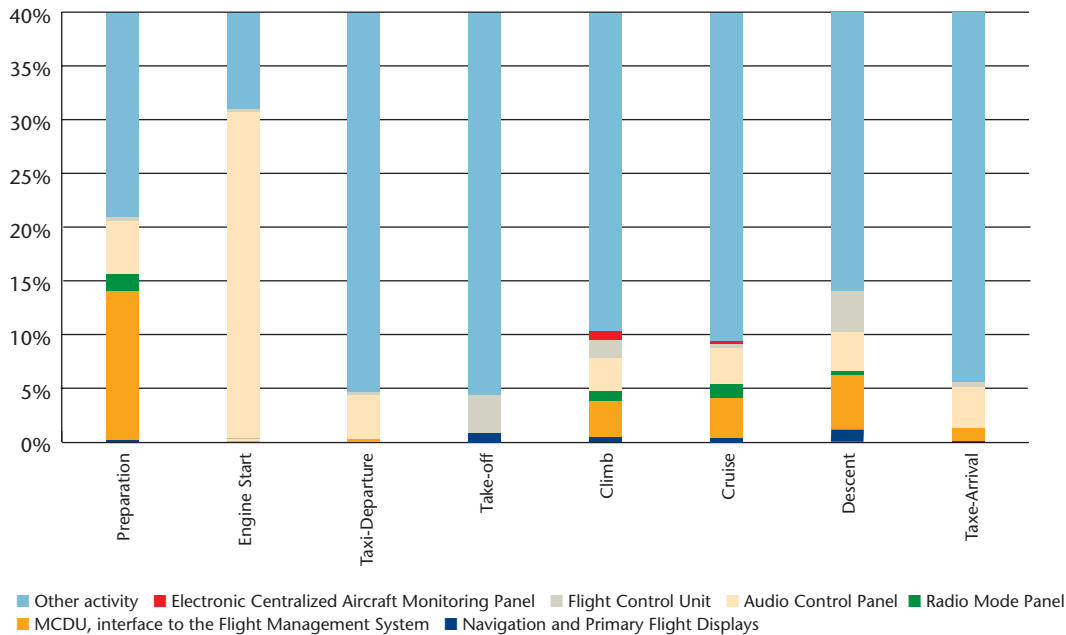


Figure 1: Human factors in aviation; what happens in the cockpit? The graph shows the time spent on manual activities for the "pilot flying" (PF). The data was collected during two real flights.

analysis are shown in Figure 1, where the manual activities in the different phases of flight are shown. The results from the analysis will be used for the evaluation of the final system.

The SEE project, which is developing two un-cooled IR cameras, will design and validate a simulation of IR images for automotive and avionics applications. Risø and its partners will use the developed simulation in order to evaluate, from a human factors point of view, the advantages of the IR image.

Safety management and safety culture

A national project on safety culture and occupational accidents is being carried out in co-operation with Herring Hospital Occupational Health Department, the National Institute for Occupational Health (AMI) and the Danish Technical University. A safety culture questionnaire has been developed, incorporating results and experience from the partners' previous projects as well as other Nordic and international sources. The questionnaire was validated in a pilot test and has been used to survey 1 300 respondents in two construction and three production sites. In addition, AMI and Risø carried out interviews about perceptions of risks and attitudes to safety among construction workers. The pilot test was very promising, and a strong relationship between the results of the questionnaire survey and actual safety performance can

be shown, which means that the questionnaire instrument is diagnostic and can discriminate between good and bad safety performance.

Within the EU-sponsored ARAMIS project, a framework for the assessment of safety management and safety culture was developed, that can be incorporated in the risk analysis outcome of hazardous process industries (industries covered by the "Seveso-II" directive on control of major-accident hazards involving dangerous substances). The key element in the approach is the set of safety barriers that should be implemented and maintained in order to control the hazards. The audit system, developed by the Technical University of Delft, addresses the management functions that need to be in place to guarantee the continuous functioning of the safety barriers.

Risø's contribution focussed on the adjustment of the previously mentioned questionnaire to assess safety culture in the process industry, which determines how the work force will perform the tasks that follow from the management functions. Example of a safety barrier involving hardware elements and behaviour is shown in Figure 2.

Assistance to EU candidate countries

The programme assisted in the so-called PHARE-twinning projects, on implementation of the Seveso-II directive on

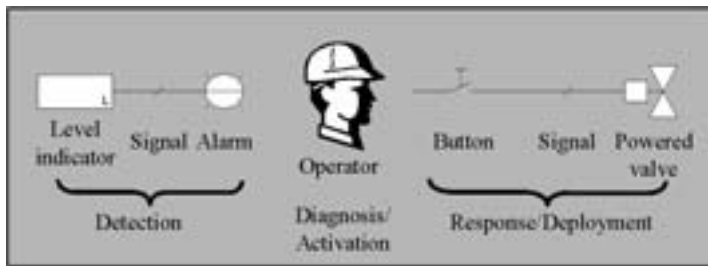


Figure 2: Example of a safety barrier involving hardware elements and behaviour

control of major-accident hazards involving dangerous substances in Poland and Bulgaria. In total, Risø researchers spent approximately 5 weeks in these countries, presenting training courses and developing guidance documents.

Center for Cognitive Systems Engineering (CSEC)

At the beginning of 2003 a collaboration agreement was signed between the Center for Cognitive Systems Engineering (CSEC) at Risø and the Center for Human-Information Interaction (CHII) at the University of Washington, Seattle. The main objective of this collaboration is to perform innovative research to maximize the effectiveness of complex information systems within dynamic work environments with rapidly evolving technology. Another important objective is to establish education and training that can be exploited by industry and the public sector. The inauguration of this collaboration was celebrated at Risø with a Seminar on Cognitive Systems Engineering, with invited speakers from the USA and Australia.

In 2003 CSEC also became a member of the core group that took the initiative to establish the Cognitive Systems Engineering Consortium. This core group consists of General Motors, Wright Patterson Airbase, Klein Associates, Wright State University, University of Ohio, Georgia Institute of Technology and Risø National Laboratory. The aim is to advance the state of the art and practice of Cognitive Systems Engineering, by applying its capabilities to real world problems in the public and private sectors, and developing the next generation of leaders in the field. The Consortium is headed by General Motors.

The CSEC hosted the Annual Meeting of the Technical Committee on Human- Computer Interaction (TC.13 on CHI) within the International Federation of Information Processing (IFIP). The 2-day event took place at Risø in February, with 20 IFIP representatives drawn from all over the world.

During Spring 2003 a 3-months graduate course on the Methods of Cognitive Work Analysis took place at the University of Washington. Staff from CSEC participated

both in the development of the curriculum and in the actual teaching sessions. The course was well received and is, therefore, now permanently established at the university.

CSEC also organized an international workshop on web-based collaboratories, held in connection with the IADIS www/Internet Conference in Algarve, Portugal, in November 2003. The workshop focused on three main issues: human factors, new understandings of the nature of science and scholarly work, and new collaboration paradigms. The workshop was co-sponsored by the EC's Information Society Technologies Programme.

Formal co-operations

Apart from the above-mentioned agreement between CSEC and CHII, the research programme participates in a number of other formal co-operation agreements.

The programme has, for many years, co-ordinated the Danish contribution to the OECD Halden Reactor Project (HRP). In 2003, the HRP renewed its contracts with the member states for another three years.

A previous collaboration with the Danish Maritime Institute was renewed and intensified after FORCE-Technology joined with DMI. The new co-operation agreement with FORCE-Technology-DMI led to the establishment of the Danish Human Factors Centre (DHFC). The DHFC was presented to interested partners and clients during a lively arrangement in November, hosted by FORCE-Technology. At the presentation, there were a variety of demonstrations, posters and small talks about all the research and consultancy services that can be offered by staff attached to the DHFC.

Energy, Environment, and Development Planning, UNEP Risø Centre

The programme is the institutional framework for the UNEP Risø Centre on Energy, Climate and Sustainable Development and, working in partnership mainly with UNEP and developing country institutions, is recognised as a leading international research and advisory centre.

Activities at the Centre focus on development of analytical tools, analysis of global, regional and national energy, climate and sustainable development issues and building analytical and planning capacity in developing countries.

Main events in 2003

The overall trend has been a continued expansion of activities in all three substantive areas of energy, climate and sustainable development. In order to manage this expansion and ensure continued development of ideas and projects, an internal matrix structure was put in place early in the year with a coordinator for each thematic area.

At the same time it was agreed with the founding institutions UNEP, Risø and the Danish Ministry of Foreign Affairs, to change the name of the Centre from the UNEP Collaborating Centre on Energy and Environment to the UNEP Risø Centre (URC) on Energy, Climate and Sustainable Development. This change was fully implemented by the middle of the year and reflects, in part, the fact that the activity areas have developed significantly since the Centre was created in 1990 and, in part, the fact that several new UNEP Collaborating Centres have been created and a more distinct profile was required.

The Secretariat for the Global Network on Energy for Sustainable Development (GNESD) was established at Risø in 2003 and located in connection with the URC, thereby benefiting from its administrative services and premises. The GNESD is a UNEP facilitated Type II initiative from the World Summit on Sustainable Development and while its activities are described in a separate section, it should be noted that the URC was appointed as one of the 20 members of the GNESD late in 2003, reflecting the international recognition of the Centres' work.

Internally at Risø the URC has been coordinating the establishment of a new inter-departmental network on Energy for Development. This network will be formally launched in 2004, with the aim of strengthening Risø's position as a leading international institution dealing with energy for sustainable development.

Energy Theme

Rural Energy Enterprise Development

AREED and B-REED are UNEP initiatives in Africa and

Brazil, respectively, supported by the United Nations Foundation, with involvement from both UNEP Risø Centre and UNEP DTIE (Paris). Enterprise development is carried out by the US-based E&Co, working with partner organisations in the five African countries, Ghana, Mali, Senegal, Tanzania and Zambia, and in North-eastern Brazil.

During 2003, AREED continued to focus on creating small and mid-size energy enterprises, using a combination of business development services and seed financing. At a Partners Meeting held in March 2003, partners agreed on a set of measures by which to increase the number and rate of investments and mobilize government and donor support for the deepening and expansion of the initiative.

The year saw a dramatic increase in the total number of AREED enterprise investments from 8 in 2002 to 21 in 2003, covering a broad range of clean energy products and services.

During 2003, B-REED identified over 40 potential investment opportunities, provided enterprise development services to 16 entrepreneurs and approved 5 investments. B-REED also provided policy support to favour the development of small energy enterprises. The first policy activity focused on the implementing regulation of a recent electricity law, and included stakeholder consultations, a policy workshop and development of a policy paper. Participants in the workshop concluded that small enterprises could play an essential role in the supply to remote locations, through an outsourcing arrangement with concessionaires, and that they could make pre-electrification possible.

The policy paper concluded that small power plants should receive the same benefits as bigger "authorized" plants, which have preference in existing funding mechanisms. At the same time, existing subsidies must be extended to off-grid consumers.

Renewable Energy and Energy Efficiency

• Financing Indian Solar Home Systems

Two partner banks, the Canara Bank and the Syndicate Bank, launched loan schemes for Solar Home Systems (SHS) in 2003, with URC support to reduce financing costs from funds provided by the UN Foundation and Shell Foundation. The first project performance review was carried out in October 2003 with satisfactory findings, and the number of SHS loans reached 1672 during the first six months of operation. The banks held regular, village-level meetings and SHS demonstrations were organized by the vendors. In addition, other banks have also shown an interest in launching similar loan schemes.



John M. Christensen
Head of Research
Programme

- *Renewable Energy Financing in the Mediterranean Region (MedREP) Project*

MedREP aims to investigate different options for increasing finance flows to renewable energy companies and projects in target countries, and to help structure support mechanisms that help lenders and investors scale up financing. Tunisia, Morocco, and Egypt are the first three target countries. Local banks and financial intermediaries have been identified in each of the countries, with a view to cooperation during the implementation phase. In 2003, URC prepared a baseline study for various renewable energy technologies in Egypt to assess their commercial viability.

- *Energy Efficiency Financial Mechanisms in Brazil, China and India*

The project focus is on devising new approaches to finance energy efficiency projects and sharing of experiences. Highlights in 2003 included a "Roundtable on Energy Efficiency Financing" in April, a workshop on "Developing the Business of Energy Efficiency Performance Contracting" in August, in Brazil, an "Energy Efficiency Projects Financing Meeting", an "International Exchange of ESCOs from China, India and Brazil" in November, in China, and a "Business Meet" in May, in India. The project website (<http://3countryee.org/>) allows dissemination and sharing of documents with other stakeholders.

- *Stimulating EU-Indochina New and Renewable Energy Projects*

The project aims to promote clean, renewable and economical energy power supplies by encouraging project cooperation between private firms and financial institutions in Europe and Indochina. The project also aims to improve and increase opportunities to transfer European technology and know-how. The project leader, the Regional Institute of Environmental Technology (RIET) of Singapore, established a network in Europe and Indochina to identify and attract the most relevant European investors. URC assisted in the establishment of the network and undertook research on the market demand, project opportunities and other information.

Power Sector Reform

The main highlight in 2003 is the publication of the report, *Electricity Reform: Social and Environmental Challenges*. Other activities include project proposal development and participation in several international conferences and workshops on environmental and social

aspects related to power sector reforms in developing countries.

Energy for Sustainable Development: Concepts and Practices

On the basis of the experience gained in the Sustainable Energy Advisory Facility (SEAF) programme completed in 2001, a study was carried out in 2003 with the explicit aims of developing a conceptual framework for analysing and assessing how energy-related projects and policies contribute to sustainable development; and illustrating the application of the framework to specific case studies.

The conceptual framework was based on recent work on the sustainability of complex adaptive systems. In its essence, the approach assesses sustainability in terms of a number of system "orientors" characterised by indicators. The approach has been applied specifically to three examples of energy interventions: photovoltaic solar home systems for poor rural households in Africa, multi-functional platforms in Mali powered by Jatropha oil, and a wind farm at Zafarana in Egypt.

Climate Theme

Capacity Development for the CDM (CD4CDM)

The 'Capacity Development for Clean Development Mechanism' project was launched in February 2002, with funding from the Ministry of Foreign Affairs of the Netherlands, and will be completed by the end of 2005.

In 2003, the project is moving from Phase I to Phase II, establishing and consolidating the Designated National Authority (DNAs) and starting the identification of potential CDM projects. By the third quarter of 2003, two main tasks were achieved in all participating countries: (i) sensitising the government support and; (ii) developing capacity of policymakers. Six countries now have DNAs and are actively working to participate in the CDM market. Training for DNA staff and national stakeholders has been conducted through various workshops and training sessions. In 2004, DNAs are to be established and operational in all project participating countries.

In addition to on-site project implementation, URC, working with regional centres and international experts, is developing various background materials for capacity building activities. A new 'CDM Information and Guidebook' was published and distribution commenced at COP9 (the 9th Conference of the Parties) in Milan, Italy in December 2003. Other background materials, such as CDM and Sustainable Development, CDM Legal Issues



Figure 1: Institutional arrangements for CDM in the Philippines

Guidebook, Peru's Institutional Strategy to promote the CDM, will be available by mid 2004.

Assessments of Impacts and Adaptations to Climate Change (AIACC)

The AIACC is a large GEF funded UNEP programme and URC implements one of the sub-projects, with the broad objective to develop the capacity to estimate and compare the benefits and costs of projects in natural resource sectors that reduce the expected damages from climate change in Southern and West Africa.

URC has two activities underway under this project. The first involves improving an existing spatial equilibrium model of the Berg River Basin and then using it to estimate the adaptation benefits and costs of two options: constructing a storage reservoir and/or implementing water markets. The second activity is an assessment of the adaptation and benefits and costs of improving crop management in Gambia to avoid extreme droughts. The benefits of crop management are being estimated as the net reduction in food import, costs less than the costs of improved management. The project will be completed in January of 2005. Two reports will be completed for the project and several journal articles will be prepared.

Emissions Trading Report

URC with KEI (the Korea Environment Institute) and IGES (Institute for Global Environmental Strategies) has produced a policy report titled "Domestic Greenhouse Gas Emissions Trading Schemes". Seven experts from five countries (Denmark, Korea, Japan, Canada, and the U.K.) made a contribution to the report.

In this study, the current status of Greenhouse Gas Emissions Trading Systems is analyzed and policy recommendations for the future direction are presented.

IPCC

The scoping of the Fourth Assessment Report (AR4) of the IPCC has, in 2003, involved a number of initial thematic discussion, where URC staff has participated in general scoping sessions and workshops on major conceptual and empirical issues related to the assessment of mitigation policies including technology, cost, and sustainable development perspectives. John Christensen was elected vice co-chair of Working Group III of the IPCC Bureau in 2002, but had to leave the Bureau again due to his URC/GNESD position being changed to a UNEP one and therefore incompatible with representing a region politically in an intergovernmental body. The Danish Government has subsequently appointed Hans Larsen as new vice co-chair, so the Departments involvement in the IPCC Bureau will remain the same.

Sustainable Development Theme

Development and Climate Change

Sustainable development policies are increasingly recognised as an important framework for energy policies, climate change and other environmental issues in developing countries. Key priorities of developing countries include, general economic and social development and access to energy, while environmental concerns and in particular climate change is a secondary or longer-term priority. However, several international studies have demonstrated that there are strong linkages between sustainable development policies and environmental improvements, for example energy efficiency improvements will, in most cases, both improve access, reduce costs, and mitigate pollutants.

URC has participated in an international research network on Development and Climate, in a partnership with 12 institutes from developing and developed countries. It explores the idea that a less polarised way of meeting the challenges of sustainable development and climate change is to build environmental and climate policy upon development priorities that are vitally important to developing countries.

The principal aim of the Development and Climate Project is to identify development paths and actions linked to positive climate change adaptation and mitigation policies.

A number of methodological challenges arise from the study of synergies between sustainable development and climate change, including the need for developing alternative long-term scenarios, which can be assessed in relation to specific sustainability criteria applied to national policy evaluation.

National Scenario Indicators	Energy Sector Indicators	Food/Water Sector Indicators
GDP	Economic costs	Economic costs
Energy sector product	Primary energy structure	Main products
Food/water sector product	Final energy structure	Total food production
Primary energy consumption	Local air pollution	Local pollution
Power supply	GHG emissions	GHG emissions
Domestic Food consumption	Energy access	Food and water access
Water consumption	Equity	Equity
% of people below poverty line		
GHG emissions		

Table 1: Examples of SD Indicators

The challenge is to identify a relevant and operational standard for representing the SD objectives. It should be recognised here that the SD objectives have a multi-dimensional character, representing various economic, social, local- and global sustainability dimensions, so the evaluation of different scenarios and policies will result in a broad range of information. Table 1 gives an overview of examples of indicators that can be used to evaluate SD dimensions of national and sectoral policies.

The general SD indicators shown in Table 1 include at the national level GDP and energy and food sector economic outputs. A few physical indicators like primary energy consumption, power production, food and water supply are also included in addition to GHG emissions. Finally, the indicators measure the percentage of people below the poverty line. The more specific energy and food sector indicators are more detailed representations of the national indicators, and include a number of additional measures of local pollution, energy/food access, and equity.

The SD indicators applied in the Development and Climate project also reflect, to a large extent, a number of the energy and food/water access issues that are included in the Millennium Development Goals, discussed by the World Summit on Sustainable Development in Johannesburg in August 2002 (UNDP, 2002).

Poverty, Risk and Vulnerability

A Ph.D. project assesses the relationship between fluctuations in income and consumption for poor households and external factors such as weather, prices or health. The study includes an empirical assessment of consumption patterns and vulnerability based on household data for Ethiopia.

Another dimension of the Ph.D. project is to reveal

linkages between poverty and environmental degradation, with a particular focus on the vulnerability of the poor to the impacts of climate change.

Network for Environmentally Sustainable Transport in Latin America and the Caribbean (NESTLAC)

Increasing income levels in many of the developing countries of the LAC region are leading to changing lifestyles and new patterns of mobility. This inevitably implies increasing demand for transportation. In the absence of appropriate and efficient public transport systems, the demand for speed and comfort will continue to promote the switch away from public transport (buses and trains) and non-motorised transport (walking and cycling), towards motorised private transportation.

The NESTLAC project addresses these issues by establishing a network of cities for Latin America, with the aim to promote and facilitate the implementation of environmentally sustainable transport (EST) options in the region.

The project has, in 2003, been established as a GEF project development activity and the plan is to continue in the next years with a full-scale GEF project, involving studies for a number of cities including Concepción, Chile; Guatemala City, Guatemala and San Salvador, El Salvador. The project involves collaboration with the Economic Commission for Latin America and the Caribbean (ECLAC).

Global Network on Energy for Sustainable Development (GNESD)

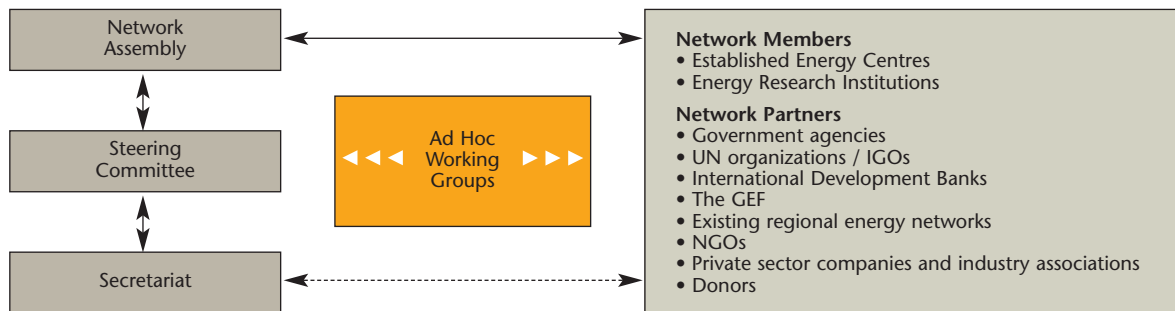


Figure 1: Network Structure

The GNESD was established as a Type II Partnership at the World Summit on Sustainable Development in 2002 and intermediary arrangements established to get the Network moving were formalised in 2003, with a Secretariat being established as a separate unit in the Systems Analysis Department, with the task of supporting the Network Members in implementing the Network's overall mandate. The Secretariat provides the Assembly, Steering Committee and Network Members with technical support, and undertakes tasks as requested by the Network Assembly and Steering Committee.

The GNESD objective is to expand the knowledge base concerning the environmentally sound provision of energy services. In order to do this the Network provides a framework and supports collaborative activities, including information exchange, learning, analysis and study; policy support, and capacity building, with a focus on issues of concern to developing countries. The Network links the knowledge, the experience and the skills available amongst its members, and through its activities benefits decision-makers, predominantly in developing countries, in both the public and private sectors.

The Network's knowledge generation activities are structured around selected thematic issues. Ad hoc Working Groups are formed among those Network members interested and able to contribute to developing knowledge about a particular thematic issue. Working Group members collaborate on information exchange, analytical studies, policy support, and capacity building.

In November 2002 *Energy Access* was launched as the first theme of the GNESD. Since then, Member Centres in eight developing countries have prepared reports investigating energy reform options with regards to securing access to electricity for the poor. This work has been based on extensive case studies in each Centre's region; findings were presented at the first Network Assembly. A Policy Summary and a Synthesis Report are currently being finalized and workshops targeting policy

makers in the various regions are being planned for 2004.

In summary, some of the key findings of the Energy Access I theme are:

- Without political commitment the impact of power sector reforms on the poor has been neutral or negative.
- Need for "ring-fencing" finances for electrification of the poor.
- Need for explicit focus on the poor.
- Focus on the sequencing of reforms, by first embarking on increasing access prior (or in parallel) to privatization;
- Consultations with poor households on the electrification process.

Based on the full set of findings, the Energy Access Working Group has prepared a set of policy recommendations, which will be published in the above-mentioned Summary for Policy Makers (SPM).

The first Network Assembly was held in November in Nairobi, Kenya. The delegates included Interim Steering Committee members, Network Partners and a number of potential new Member Centres.

The Assembly delegates approved the GNESD Structure Document that formally established bylaws and a two-year work programme/budget for 2003 - 2004. The GNESD Steering Committee was also formally established and includes representatives from donor governments and Member Centres in both developing and OECD countries. Delegates also decided to invite an additional number of Centres to join the Network as members, increasing the total number of members to twenty.

The Assembly also approved two new substantive themes. The first is to continue the Energy Access work in an *Energy Access II* theme, disseminating the findings from the first phase, focusing on policy recommendations and approaches for improved access to electricity, and secondly to initiate a new *Renewable Energy Technologies* (RETs) theme to be operational early 2004.

Energy Systems Analysis



Frits M. Andersen
Head of Research
Programme

The research programme develops methods for analysis of energy, environmental and economic issues, as well as analysis of new technologies and their interaction and adaptation into a complex European energy system. Jointly with the Department for Policy Analysis at the National Environmental Research Institute (NERI), the Energy Systems Analysis research programme at Risø form the Centre on Environment, Economy and Society (CASE). The research areas covered by the centre are energy and environmental economics, integrated environmental information systems, estimates and forecasts of energy use and emissions and sector analyses within land use, transport, and energy.

Major activities in 2003 within the Energy Systems Analysis Programme were:

- An EU project on Wind Power Integration in a Liberalised Electricity Market (WILMAR)
- Analyses of research and development in renewable technologies in liberalised energy markets
- Analysis of interaction between liberalised markets for electricity, district heat and natural gas, and to quantify efficiency losses due to market power.
- Assistance to the Lithuanian Ministry of Economy on Economic and Energy modelling

Other activities were concerned with – analyses of renewable energy markets, investments, support mechanisms for the promotion of renewable technologies in Europe and the development of the electricity net in relation to renewable technologies, – market imperfections in the European electricity market and its implication on European economy and environment, – security of supply in the Nordic electricity market and how market regulations may secure sufficient production capacity, and – analysis of new, hydrogen based, technologies and how these may be integrated into future energy systems.

Wind Power Integration in a Liberalised Electricity Market (WILMAR)

The research project WILMAR (Wind Power Integration in Liberalised Electricity Markets), is supported by the European Commission under the Fifth Framework Programme. The project was launched, for an overall duration of 36 months, in November 2002

The main task of the project, in which three industrial partners collaborate with several scientific institutions, is to analyse the technical and economic impacts of introducing different shares of wind power in a large electricity system, where the dispatch of the power producing units is determined through trade on electricity markets. A key issue when studying wind power impacts is to give a

proper representation of the stochasticity of wind power production. One of the main efforts of the project is, therefore, to develop a large stochastic optimisation model (hereafter called the Planning model) to simulate alternative system configurations, thereby offering an input for decision-making by system operators, power producers and energy authorities. It is expected that the final model, complete with data, will be the first of its type in the public domain.

With a starting point in the Balmorel model (see www.balmorel.dk), an hour-by-hour stochastic optimisation model of an electricity system [where the basic dispatch of the power producing units is governed by trade on a day-ahead market and a regulating power (intra-day) market] is developed. This Planning model is used to investigate the technical and cost issues of integrating large amounts of wind power into the electricity system. The Planning model will cover two power pools: Nord Pool and European Power Exchange (EEX), i.e., Germany, Denmark, Norway, Sweden and Finland. It will be tested by different end-users, for instance, systems operators and power producers, who are also expected to be users of the final Planning model.

The second main effort in the project is to analyse the issue of system stability, i.e., the wind integration aspects connected to the fast (less than 10 minutes) fluctuations in the wind power production, with the use of dedicated power system simulation tools. It includes the analysis of a number of case studies, especially selected for large-scale integration of renewable energy generation and with expected potential stability problems. The worst cases will be selected based on input from model runs with the Planning model.

Finally, the results obtained will be summarised and used to provide recommendations about the technical integration possibilities, the integration costs of wind power and the organisation of power pools.

For additional information about the project please visit the WILMAR homepage www.wilmar.risoe.dk.

Support, research and development of renewable energy technologies at liberalised market conditions

The goal of this project is to discuss subsidy schemes for research and development (R&D) and other support of renewable energy technologies.

The development of technologies to generate electricity based on renewable energy has, for many years, had a high political priority in Denmark. For some technologies, such as windmills, the development has been a success. For other technologies, however, the development has been slow. What is the explanation for these

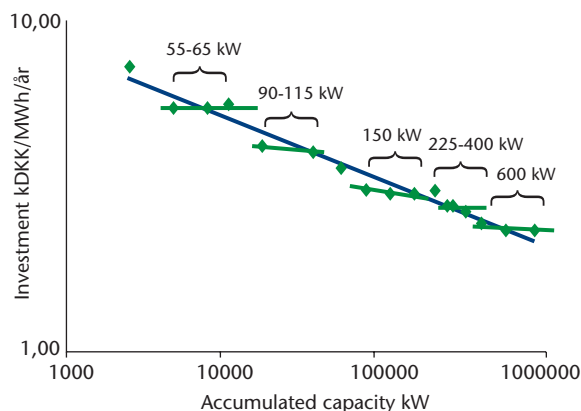


Figure 1: Plateaux in the experience curve (process innovation) caused by scaling effects (product innovation)

different experiences? Can success be achieved just by duplicating the support portfolio from windmills?

This project tries to answer these questions. The project deals with the development of renewable energy technologies – by theoretical as well as empirical analysis. The basic idea is that a political decision to support the development of a technology does not guarantee that the technology becomes so reliable and effective that it can compete with other technologies.

The results of the project are published in a book: Skytte, K., Jensen, S.G., Morthorst, P.E. and Olsen, O.J., *Støtte til vedvarende energi?*, DJØF-Publishing, Denmark, 2004.

Figure 1 shows an experience curve for wind turbines in Denmark. The small squares represent the observed data, whereas the bold line is the experience curve estimated on the basis of observations. A double logarithmic diagram illustrates the experience curve as a straight line. There are plateaux in the observed data, in accordance to the most dominating windmill sizes at the time of observations. This indicates that both process and product innovation is important in the development of windmills.

Interaction between liberalised energy markets

In recent years the liberalisation of energy markets has gained momentum and has resulted in the creation of large electricity markets in Europe. Liberalisation is also taking place within the natural gas sector and to some extent for Combined Heat and Power production. Energy markets are interconnected via the fuels used for producing heat and electricity and the fact that, for many applications, energy types are substitutes.

A project carried out by Risø and AKF describes the links

between energy markets that have recently been liberalised or in which liberalisation is under consideration. The markets for electricity, natural gas and district heating are interlinked, both with respect to the energy flows and with respect to ownership of supply sources and infrastructure. The extent and the possible consequences of these linkages are examined. The options for public interventions in the markets are analysed, in order to compare instruments with respect to their ability to provide the necessary incentives for an efficient functioning of the liberalised markets. Both aspects of retail markets with households facing multi-product distribution companies and aspects of the production of combined heat and power based on natural gas are covered.

So far, much of the concern has focused on the production and wholesale markets for electricity, analysing the efficiency of markets and market power issues. This project identifies important aspects related to the final consumers and the interaction of markets with different types of regulation and scope for liberalisation. From a Danish perspective the district heat market and the dependence on market conditions for natural gas is a specific concern. Consumer concerns also relate to the creation of multi-product energy distribution companies that are privately owned and possibly controlled by foreign interests. Such companies may use bundled sales of energy products to exert a dominant position in one market e.g. a regulated heat market to a market with considerable competition (electricity). Bundled sales do not necessarily result in a loss for the consumer, but the regulatory authorities responsible for district heat prices will have a more complicated job in surveying the bundled price setting.

The markets for electricity and heat were examined with respect to their dependence on natural gas supplies and the possibility of limited competition in gas supplies. Integration of activities within natural gas distribution and CHP production are analysed with respect to incentives and welfare implications. Results of the project point to critical market conditions and identify areas of concern for regulatory policies. It is possible that small Combined Heat and Power plants based on natural gas will be considered as minor customers for new entrants into the Danish supply markets and thereby will be charged higher prices than their larger competitors in the electricity markets (large scale CHP). Furthermore, the possible integration of gas supply companies with Combined Heat and Power producers involves three major energy markets and is of specific importance in the Danish case.

Welfare implications of different market developments were analysed with respect to gas and electricity integra-

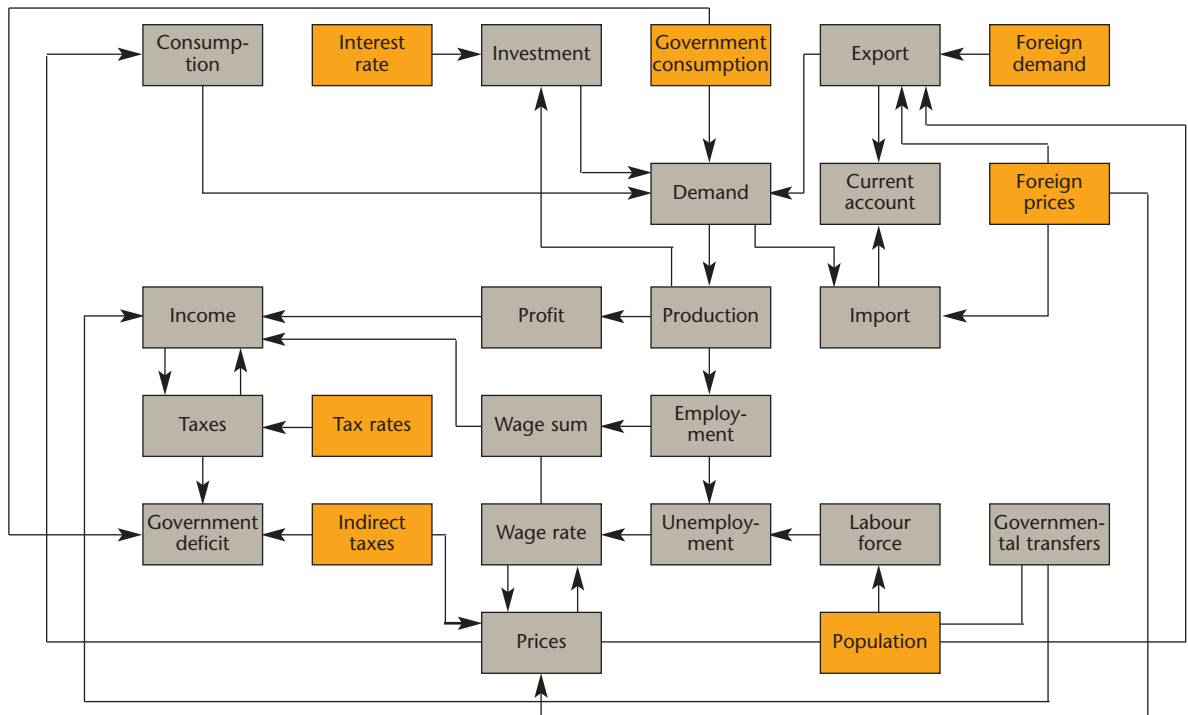


Figure 2: A flow chart of LITMOD

tion. The analysis shows that there is a large welfare loss associated with having monopolies in both natural gas supplies and CHP production. If liberalisation allows integration of these two energy markets welfare would be improved. The analysis shows, moreover, that the existence of differentiated electricity production technology (fuels) reduces the welfare loss from a monopoly in the natural gas supply, even though the natural gas keeps a high market share. Integration in this case still reduces the welfare loss from the limited competition in the two markets, but this is much less important in this case.

Assistance to the Lithuanian Ministry of Economy on Economic and Energy modelling

Providing support from the Danish Energy Authority to the Lithuanian Ministry of Economy, the Energy Systems Research Program has been involved in the development of models for the Lithuanian economy and energy demand.

In collaboration with the Lithuanian Energy Institute, satellite models for the energy demand model MAED have been elaborated. MAED is a technical scenario model in the family of MEDEE models and was implemented for Lithuania before the project started. The satellite models developed comprise an econometric model for the energy demand by branches and for heating within households, and a technical appliance model for the electricity demand by households.

A central input to the energy models is economic

development. To obtain consistent economic projections a new version of the macro-economic model LITMOD has been developed. LITMOD is a medium-term, demand-driven Keynesian macro-econometric model of the Lithuanian economy, including elements of supply-side modelling. A first version of the model was developed by Arvydas Kazlauskas and August Leppä within the Lithuanian Ministry of Economy.

In collaboration with the Institute of Economics of the Lithuanian Academy of Science, LITMOD has been updated, re-estimated and partly re-formulated. An important part of the work has been the development of proper model documentation, documenting both the theoretical considerations and the actual estimated equations.

The model mainly determines the real flows of the Lithuanian economy, with a 12-sector input/output table as a central element. The model is estimated on quarterly data for the period 1995 to 2002.

A simple flow-chart of LITMOD is shown in figure 2 where the yellow boxes are exogenous variables.

The revised model has been delivered to the Lithuanian Ministry of Economy and will be further enhanced by a group at Vilnius University, developing a "Mathematical Model of Lithuanian Economy for Forecasting of the Macroeconomic Processes (LEMM)". This group will develop two models, a CGE-model for long-term forecasts of the Lithuanian Economy and a multi-sectorial, macro-econometric model for short- to medium term forecasts. The revised LITMOD may be seen as a starting point for the macro-econometric modelling.

Summary Statistics

By the end of 2003 the total number of employees in the department was 68, of whom 26 were female and 42 male. More than 90 per cent of the staff has an academic background. The age distribution shows that approximately one-third of the staff are between 30 and 39 years of age. One-quarter is in the range 40-49 and one-quarter 50-59 years of age.

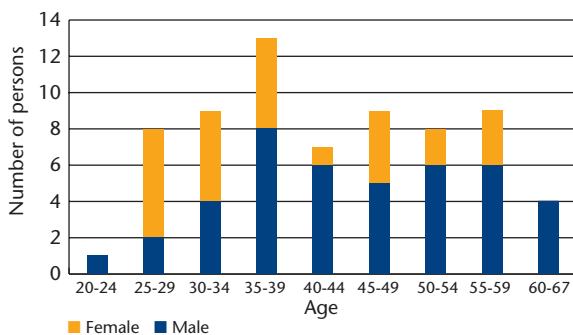
The number of publications in 2003 totalled 128. The number of international publications fell from 42 in 2002 to 36 in 2003. A drop is also seen in the number of international reports as well as Danish publications,

In 2003 total gross/net turnover amounted to DKK 71,6 mill/DKK 53,6 mill (EUR 9,6 mill/EUR 7,2 mill). Seventy per cent of the department's activities were financed through national and international research contracts, including commercial contracts while the remaining 30 per cent of the activities came from government appropriations.

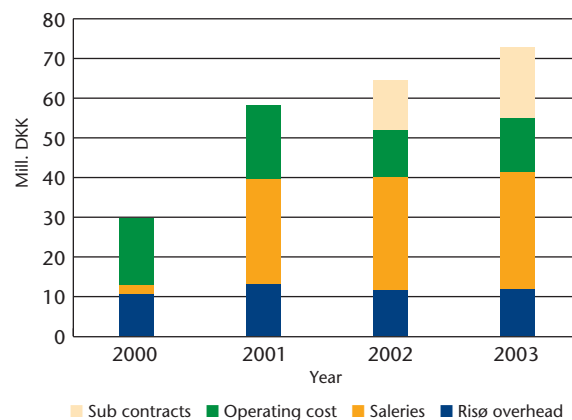
Staff 2003

	Females	Males	Total
Academics:			
Head of department and programmes	0	5	5
Research specialists	1	1	2
Senior scientists	6	24	30
Scientists	4	4	8
Technical/administrative staff	6	3	9
PhD students	5	4	9
Technicians	0	1	1
Secretaries	4	0	4
Total staff	26	42	68

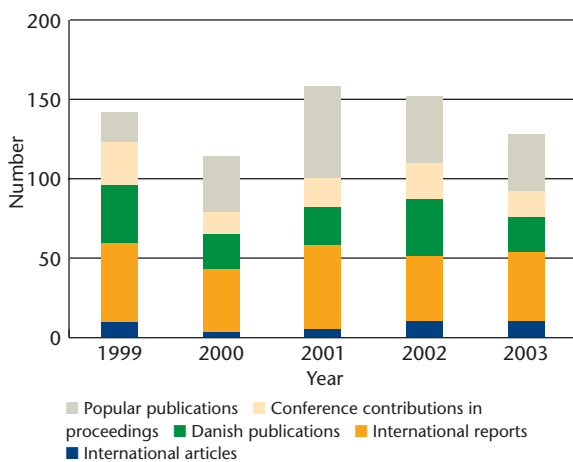
Age and gender distribution 2003



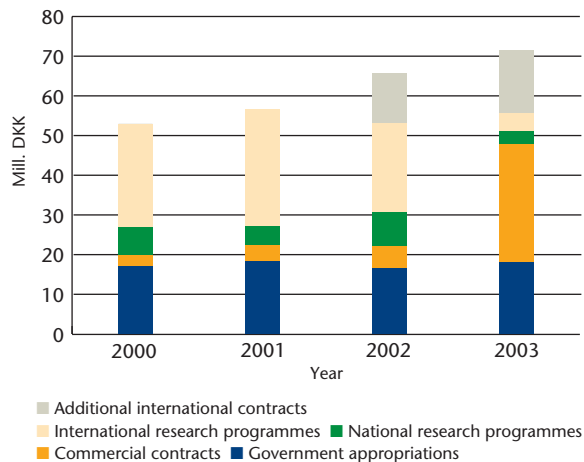
Expenditures 2000-2003



Publications



Revenues 2000-2003



Staff 2003

Hans Larsen, M.Sc., PhD, Head of Department
 Vivi Nymark, Secretary
 Charlotte Olsson, M.Econ., HD, Administrative Officer
 Cecilia Steck, Secretary

Energy, Environment and Development Planning, the UNEP Risø Centre

John M. Christensen, M.Sc. (Eng.), PhD, Head of Research Programme
 Maria Andreassen, Secretary
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 Kirsten Halsnæs, M.Econ., PhD, Senior Research Specialist
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 Anne Marie Jelsbak Jensen, M.Sc., Administrative Officer
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 Jesper Kühl, M.Sc., PhD Student
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 Ivan Nygaard, M.Sc., PhD Student
 Anne Olhoff, M.Econ., PhD, Scientist
 Karen Holm Olsen, M.A., PhD student
 Romeo Pacudan, M.Eng, PhD, Senior Economist
 Jyoti P. Painuly, B.E. (Mech.), Fellow IIMB, Senior Energy Planner
 Stéphanie Robert, M.A., PhD student
 Jorge Rogat, B.Sc., PhD, Senior Economist
 Stine Skipper, M.Sc. (Econ. and Intl. Developm.)
 Njeri Wamukonya, M.Sc., PhD, Energy Planner
 Juan Zak, M.Sc. (Mech. Eng.), Senior Energy Scientist
 Wilson Wasike, M.A., M.Phil., Ph.D., Senior Energy Planner

Energy Systems Analysis

Frits Møller Andersen, M.Econ., Head of Research Programme
 Peter Frstrup, M.Sc. (Econ.), PhD, Senior Scientist
 Dorte Grinderslev, Cand. Scient. Oecon, Research Assistant
 Poul Erik Grohnheit, M.Econ., Senior Scientist
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 Stine Grenaa Jensen, M.Sc., PhD Student
 Kaj Jørgensen, M.Sc., PhD, Senior Scientist

Helge V. Larsen, M.Sc. (Elec. Eng.), PhD, Senior Scientist
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 Lars Henrik Nielsen, M.Sc. (Phys. & Math.), Senior Scientist
 Klaus Skytte, M.Sc. (Math. Econ.), PhD, Senior Scientist

Technology Scenarios

Per Dannemand Andersen, M.Sc. (Eng.), PhD, Head of Research Programme
 Maj Munch Andersen, M.Sc., Ph.D., Scientist
 Kristian Borch, M.Sc. (Eco-toxicology), PhD, Senior Scientist
 Mads Borup, M.Sc., PhD, Scientist
 Birte Holst Jørgensen, M.Sc. (Social Sc.) PhD, Senior Scientist
 Oliver Vindex Nielsen, Research assistant
 Jon Olav Pedersen, M.Sc., PhD Student – until March
 Birgitte Rasmussen, M.Sc. (Chem. Eng.), PhD, Senior Scientist
 Cynthia Selin, MA (Sc., Tech. and Soc.), PhD Student

Safety, Reliability and Human Factors

Nijs Jan Duijm, M.Sc. (Eng.), Head of Research Programme
 Alexandre Alapetite, PhD Student
 Asmatullah Naybkheil, Assistant
 Hanne Albrechtsen, MLISc., PhD, Senior Scientist
 Hans H.K. Andersen, M.Sc. (Psych.), PhD, Senior Scientist
 Henning B. Andersen, M.A. (Philos.), Senior Scientist
 Verner Andersen, M.Sc. (Elec. Eng.), PhD, Senior Scientist
 Thomas Bove, M.Sc., PhD, Post Doc – until April
 Bryan Cleal, M.Sc., PhD, Scientist
 Kim Hvid Haagensen, M.Sc., PhD Student
 Erik Hansen, M.Sc. – until August
 Igor Kozine, M.Sc. (Systems Anal.), PhD, Senior Scientist
 Kurt Lauridsen, M.Sc. (Elec. Eng.), PhD, Senior Scientist
 Marlene Dyrlov Madsen, M.Sc., PhD student

Frank Markert, M.Sc. (Chem.), PhD, Senior Scientist
 Finn R. Nielsen, M.Sc. (Appl. Math. & Phys.), Scientist
 Jette L. Paulsen, M.Sc. (Eng.), Senior Scientist
 Christian Rud Pedersen, M.Sc. (Eng.), PhD, Scientist, until August
 Annelise M. Pejtersen, M.A., Research Professor
 Steen Weber, M.Sc. (Elec. Eng.), PhD, Senior Scientist

Secretariat for Global Network on Energy for Sustainable Development (GNESD)

John M. Christensen, M.Sc. (Eng.), PhD, Head of Secretariat
 Mila Jude, M.Eng'g, M.Sc. Programme Officer
 Per Kolbeck, M.Sc. (Int. Tech. Planning), Assistant programme officer

Senior Employees

Palle Christensen, M.Sc. (Elec. Eng.), Senior Scientist
 Niels A. Kilde, M.Sc. (Chem. Eng.), Senior Scientist

Research Technician

Erling Johannsen – until March
 Michael Nyboe

Short term guest researchers

Victor Krymsky, Ufa State Aviation Technical University, Russia
 Pablo Del Rio Gonzales, University of Castilla-La Mancha, Spain
 Farit Akhmedjianov, Ufa State Aviation Technical University, Russia

Temporary Staff

Thomas Henriksen
 Sigrid M. Rasmussen

Students

Nina Dadalauri, Roskilde University
 Cecilie Juhl Stentoft, Roskilde University
 Aurelie Pereaudeau, Ecole des mines de nantes
 Patrick Balla, Lunds University
 Rune Nørager, University of Aarhus

PhDs awarded in 2003

Jon Olav Pedersen, M.Sc., Copenhagen Business School
 Hanne Albrechtsen, MLISc., Aalborg University

Mission

Risø's mission is to promote an innovative and environmentally sustainable technological development within the areas of energy, industrial technology and bioproduction through research, education, innovation and advisory services.

Vision

Risø's research shall extend the boundaries for the understanding of nature's processes and interactions right down to the molecular nanoscale.

The results obtained shall set new trends for the development of sustainable technologies within the fields of energy, industrial technology and biotechnology.

The efforts made shall benefit Danish society and lead to the development of new large industries.

Risø's activities in 2003 are reported in the following publications: Risø Annual Report (available in Danish and English), Risø's Annual Performance Report (Danish) and the annual progress reports of the research departments (English). All publications and further information can be obtained from risoe.dk. Printed publications are available from the Information Service Department, tel.: +45 4677 4004, e-mail: risoe@risoe.dk, fax: +45 4677 4013.

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