



Energy research Centre of the Netherlands



2006

ANNUAL REPORT



Annual report 2006

Preface	2
Introduction	4
Policy Studies	8
Research Energy Efficiency in Industry	12
Research Built Environment	16
Research Solar Energy	20
Research Wind Energy	24
Research Biomass & Coal	28
Research Hydrogen	32
Research Intelligent Energy Grids	36
Research Clean Fossil Fuels	40
Research Environment	42
Engineering & Services	46
Facility Services	48
Quality, Safety & Environment	50
Personnel en Organisation	54
ECN in the Public Eye	56
NRG	58
Energy Advisory Groups	62
Energy Advisory Committee	63
Supervisory Board	64
Board of Directors ECN	68
Management	69
Financial Report	70



There was no lack of interest in the subject of energy in 2006. The public slowly awoke to the fact that the high price of oil could be a permanent fixture, and even if the oil price were to decline, new increases could be expected in the future. The explosive demand for oil in Asian countries will probably continue for the foreseeable future. Despite all of the activities on this front, the transport sector is still completely dependent on the availability of oil, not only in the Netherlands but throughout the world.

The climate also received quite a bit of attention in the past year, not in the least because of the spectacular show that Al Gore used in a typical American style to put the subject on the international agenda. Scientists have also made significant progress in unravelling the mechanisms and consequences of climate change. As a result, the number of sceptics claiming that humans have no influence on climate is slowly shrinking.

Fortunately, the Dutch government has not sat still. The Energy Research Strategy (EOS) and the energy transition policy were further implemented in

2006, and the "Wijffels" exercise has been completed. The government defines the energy transition policy as follows:

'Energy transition stands for a structural change in sustainable energy use. Where current energy policy is aimed at reaching the targets for 2010, transition policy is oriented towards the period that follows. Energy transition will provide a sustainable energy supply within 50 years. Energy will be clean, affordable for everyone, and constantly available everywhere.'

In the first place, it is good that the government recognises that the realisation of sustainable energy use requires a long-term policy. This reinforces my vision that the transition must occur along four main lines:

- First, energy conservation;
- Then satisfying as much of the demand as possible with sustainable energy sources;
- Any fossil fuels used should be utilised as cleanly as possible (CO₂ capture);
- Application of nuclear power in a safe manner: safe power generation, safe re-use and waste storage, and safe with regard to a nuclear-weapon-free world.

This should eventually lead to a society characterised by the use of a sustainable energy supply. Another positive aspect of the government policy is that energy should be affordable and available for everyone. The Dutch economy grew in 2006, despite the rising cost of oil. This shows that our economy can handle a high oil price. Thanks to our prosperity and the infrastructure present, we can deal with the consequences. However, our natural gas reserves do not have eternal life. Poor countries have a much more difficult time. For them, high oil prices and rising sea levels form insurmountable barriers and increase the difference in prosperity between them and others considerably. This means that the Netherlands has the moral obligation to do the utmost to provide information and expertise to those countries.

At the beginning of 2007, the Balkenende IV cabinet took office. During the formation negotiations, the cabinet placed the energy problem high on its agenda. Energy is therefore one of the key areas in the innovation platform, and the targets for energy conservation and sustainable energy sources have been increased significantly. Of course, the Supervisory Board agrees completely with this idea, but it does have consequences. The key concept is "Knowledge". As illustrated in the Option Document, the current state of technology is insufficient to achieve the higher goals in an affordable manner. This means that new technologies will have to be realised in an accelerated pace, and more knowledge will have to be gathered. The Netherlands is too small to build up the necessary expertise in a decentralised or splintered manner (as the "Wijffels" exercise has illustrated). Therefore, ECN has taken the unique initiative to co-ordinate energy research with the technologically-oriented universities united in the 3TU-Federation. This effort has indicated that material research for new second-generation energy technologies in the Netherlands falls far behind the rest of the world. This lag is most clearly visible in investments in research facilities, and this has led to even more cuts in these investments.

ECN and the 3-TU-Federation have formulated a detailed proposal to give a new impulse to research in materials for energy technologies. This proposal,

the ADEM innovation lab, consists of significant reinforcement of research facilities among four organisations, with close attention given to avoiding overlap. The proposal also provides for optimal use and sharing of existing research facilities. In addition, proposals have been drawn up for approximately sixty doctoral students to support the research. According to the Supervisory Board, investments are absolutely vital to achieve the higher targets with the (antiquated) research facilities available, and to open the road to a sustainable energy supply for everyone.

In general, we at the Supervisory Board are satisfied with what research at ECN has achieved in 2006. Although it is increasingly difficult to fill vacant positions, our researchers have made considerable progress. Unfortunately, the pension problem hung as a black cloud above the employees' heads throughout 2006. The Supervisory Board, and myself in particular, have given this problem close attention. The solution achieved in conjunction with the Works Councils and with support from the trade unions is, in our opinion, the fairest solution that could be reached. However, it does entail a significant decrease in the company's liquid assets, and this will have to be repaired in the coming years. We hope that the directors and employees of ECN will again be able to focus completely on their research tasks in 2007, and we would like to thank everyone for their fantastic efforts in 2006.

Dr. Ruud Lubbers
Chairman of the Supervisory Board ECN



Ruud Lubbers

Introduction



"The past four years have been successful for ECN, with many appealing scientific and technical results, such as: the applications of OLGA technology for removing tar in biomass gasifying, hydrogen-powered cars, higher efficiency and lower costs for solar cell technology, new options for raising wind park capacity and preparations for new wind test facilities, steering algorithms for decentralised generation, centralised hydrogen production with CO₂ capture, removal of N₂O during ammonia production, etcetera."

The quote above is from Ton Hoff and Kees van der Klein, directors of ECN, making up the balance of the past year and illustrating the strategy for the near future. In the course of 2006, they watched the social relevance of ECN's work increase dramatically. "Many problems revolve around energy, summarised in the words supply security, climate change and sustainability. Only a transition to a clean, reliable and affordable energy system can provide a solution. At the moment however, the problems are intensifying, not diminishing: the problem of global warming is taken to be more serious, use of fossil fuels continues to rise, supplies are drying up, and fossil fuels continue to come from politically

instable regions. In the meantime, many developing countries have absolutely no access to modern forms of energy generation."

According to the ECN directors, it is increasingly clear that new technologies and perhaps entire new system approaches are necessary for the transition to a sustainable energy system to succeed. ECN's mission is to develop these. To reach this goal, the directors have drawn up a Strategy Plan for the period 2007-2011.

In drawing up this plan, the directors utilised not only analyses of presentations and perspectives, they also went to the research units to listen to employee's ideas and desires. This was to abide by the second guideline for developing a strategy plan: that the power of ECN lies in developing each employee.

Van der Klein: "ECN wishes to remain a prestigious and respected research institute known for its socially responsible business policies. The latter is essential to achieve the former. ECN's success is determined by the efforts and qualities of our employees, as well as their mutual co-operation and respect."

Hoff: "ECN is eager to perform ground-breaking research that will positively influence the energy transition. The company offers employees the opportunity to work towards that goal through challenging programs. Intensive participation in the process of transition is the ideal basis for ECN to co-ordinate its programs with both the government and the private sector." In doing so, ECN intends to counter the so-called "innovation paradox" signalled by the Wijffels study: the fact that much technology and knowledge is developed in the Netherlands, but that not all is passed on to applications. ECN therefore wishes to pay more attention to bringing technological developments to market in order to "finish the job".

2006 was also a turbulent year financially. Operationally, the year was not very successful, with a corporate return of only € -/- 2,9 million (in 2005: € 5,1 million). However, when the financial conclusion of the pension problem is taken into account, the normalised corporate return was € 7 million. Incidental positive financial development and unplanned expenses meant that ECN closed out the year with a small loss of € 1 million. Turnover rose by € 15 million to almost € 122 million; primarily due to extra subsidies awarded via the EOS project. Employees bore a much heavier work load, as approximately fifty full-time positions could not yet be filled.

The long negotiations between the directors of ECN and (former) employees resulted in a new pension plan that went into effect on 1 January 2007. As not every ex-employee agreed with this arrangement, further lawsuits against ECN/NRG in the future may be anticipated.

Payment of the indexation of pension entitlements for the years 2003-2006 did cost ECN € 16 million. 'Although more lawsuits may follow, we know that the company has done its utmost', according to Ton Hoff. 'That being said, it did cost the whole organisation a great deal of energy in 2006. Now that a solution for the pension scheme has been agreed with both union and staff councils and has been implemented as of 1st January 2007, ECN management can again concentrate their attention and energy on energy R&D. That is why the strategic plan is so important: it provides a guideline for making ECN's financial position healthy again.'

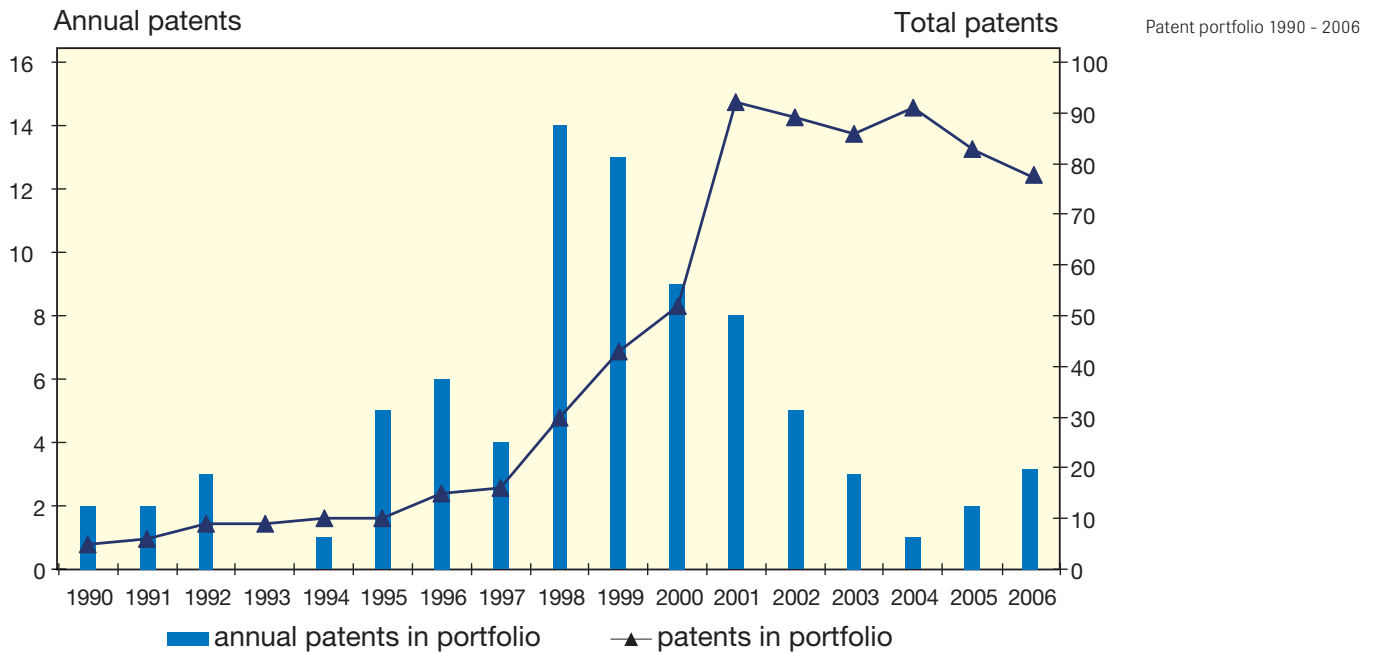
We can be satisfied with the concrete successes we have achieved. "Our role in formulating policy has been reinforced, both in the Netherlands and in Europe", the directors explain with pleasure. "The European Commission increasingly is making use of ECN's knowledge of energy policy. Our relations with the energy sector and the industry have significantly improved, and our "brand awareness" has improved due to presentations by our management, the quality of our products and all the attention given to our anniversary."

"The most concrete improvements are the results of industrial co-operation and technology transfer. Our daughter RGS (wafer technology) has been restructured, adding industrial partners and licensees. We are preparing a number of new subsidiaries, and have issued licences for various ECN patents.



The opening of the Hydrogen filling station by State Secretary Van Geel drew a lot of attention from the press. The NOS-radio Journal, ANP, RTL 4, and the newspapers Financieel Dagblad and NRC all dedicated time or print space to this event. The international press bureau Reuters even spread the news to Japan and the United States.

Introduction



In the course of recent years, we have also set up a number of spin-off subsidiaries, some of which (such as Sunlab and WEF) are already profitable. Still, transferring technologies to the market – our core interest – remains our top priority. We can still improve.”

The directors have greater ambitions. Ton Hoff: “We intend to make ECN even more a significant European player, both with the European government as well as with international corporations. But we will do so from a strong and respected national position.

Secretary Van Geel and Johan Beesteheerde.

At a ceremony to mark the successful operation of the biomass gasifying plant on Wednesday, 15 March, State Secretary Van Geel received a voucher to fill up on “Green natural gas” at ECN within the year.

In March 2006, the 1,000 hour test of the biogas installation was completed, enabling a demonstration of the production of electricity and heat from biomass. The 500 kilowatt test installation consisted of a circulating fluidised bed gasifier, in which wood is converted into gas, a purification phase to remove pollutant components from the gasification gas, and a gas motor that can produce electricity and heat with a high efficiency.





Dahlmann and ECN signing license agreement.

On Wednesday, 22 November 2006, the Energy research Centre of the Netherlands and Dahlmann Industrial Group BV have signed a license agreement on the OLGA gas cleaning technology.

Energy, climate and R&D policies are increasingly determined in Brussels, and we are also finding more demand from non-Dutch industries.”

Van der Klein: “At the same time, we intend to strengthen our relations with the universities. We hope to reach a ratio of 10-20 percent doctoral students and post docs (in proportion of the number of academics at ECN). We are now working on more intensive co-operation in new competency fields (such as material developments). We would also like to strengthen co-operation with the industry through mutual clarity about the roles we can play in the development process.”

In order to achieve all of this in the coming years, extra emphasis will be given to personnel policy. Van der Klein: “In order to perform top international research and bring it to application, you need to invest in people. On the one hand, this means that you have to stimulate enthusiasm and creative processes in the employees, and on the other you have to guarantee result-oriented research and applications. An important element of the new approach is that successes should be celebrated. All too often they go by unnoticed, and successful developments outside the unit are ignored.”

The directors are confident that in the near future, with increased attention to energy problems and the outstanding reputation of ECN in many fields, many new technological successes can be realised. These successes can only be realised through the efforts of the ECN staff and we therefore would like to thank all employees for their great personal efforts in 2006.

Ton Hoff, Managing Director

Kees van der Klein, Adjunct Director



Ton Hoff



Kees van der Klein



“The public’s interest in climate change increased significantly in 2006, and that has put our work more into the spotlight”, says Policy Studies unit manager Remko Ybema. “Energy is back on the political agenda.” Concerns about climate change, triggered by Al Gore’s movie, draw attention to energy problems, on top of other concerns about security of supply when Russia shut off the tap to the Ukraine on New Year’s Day of 2006. The risk to Europe’s largest supply of energy imports was made clear in an instant. Add to that the constant high price of oil, and you can understand the renewed interest in energy.

It is therefore not surprising that the Options Document Energy and Emissions 2005-2020 has received so much attention. This study explored all the Dutch options for reducing greenhouse gases until 2020. The document shows that the Netherlands can reduce greenhouse gas emissions by approximately 30 percent, but this will require the implementation of many different options. Increasing the pace of energy conservation is one of them, but not the only option; having the most ambitious conservation targets makes conservation relatively

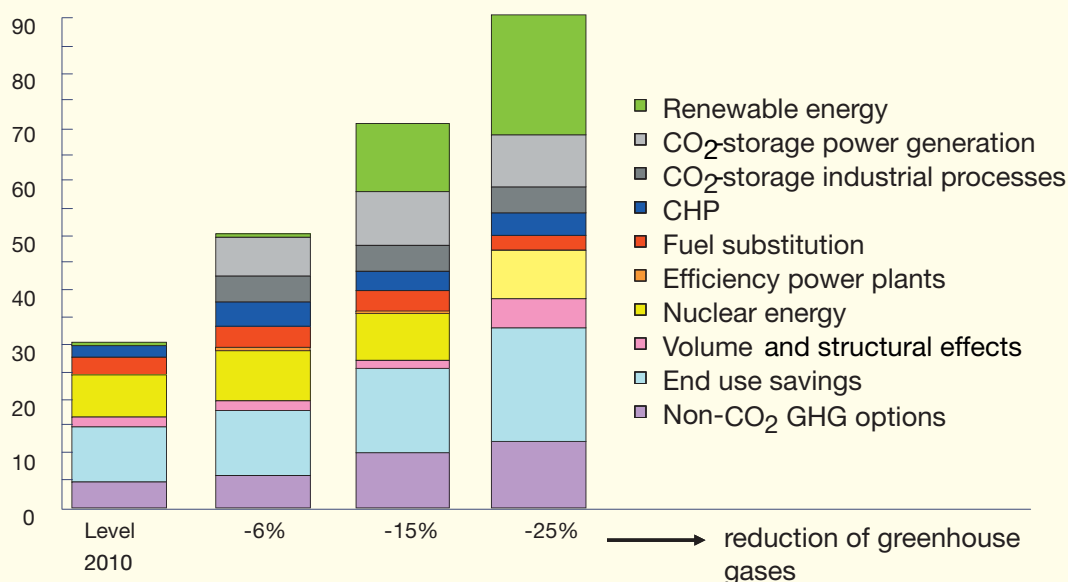
expensive. The document caused a great deal of political controversy due to Dutch State Secretary Van Geel's careful plea for more nuclear energy in the television programme "Buitenhof". The analyses from the Options Document now appear to constitute a foundation for national energy policy formation for the coming year. At the request of the Dutch Ministry of Economic Affairs and the Ministry of Housing, Spatial Planning and the Environment (VROM), analyses based on the Options Document contributed to the cabinet formation.

Much of the unit's work involves energy transition, including a framework agreement with the Interdepartmental Project Department of the Ministry of Economic Affairs. The unit provided support to the Energy transition Task force, which involved making calculations about the cumulative effect of all of the platform's plans regarding CO₂ emissions. It appears that if all plans are successfully implemented, CO₂ emissions can be reduced from 170 Mton in 2000 to 40-90 Mton by 2050.

Within the context of transition, the unit is also participating in the European projects HyWays, HyLights and Roads2HyCom. It has determined that the development conditions in the United States are more favourable than in Europe: a larger percentage of the infrastructure for demonstration projects is compensated, and the key state California plans on requiring car manufacturers to produce an increasingly larger number of emission-free hydrogen fuel cell cars.

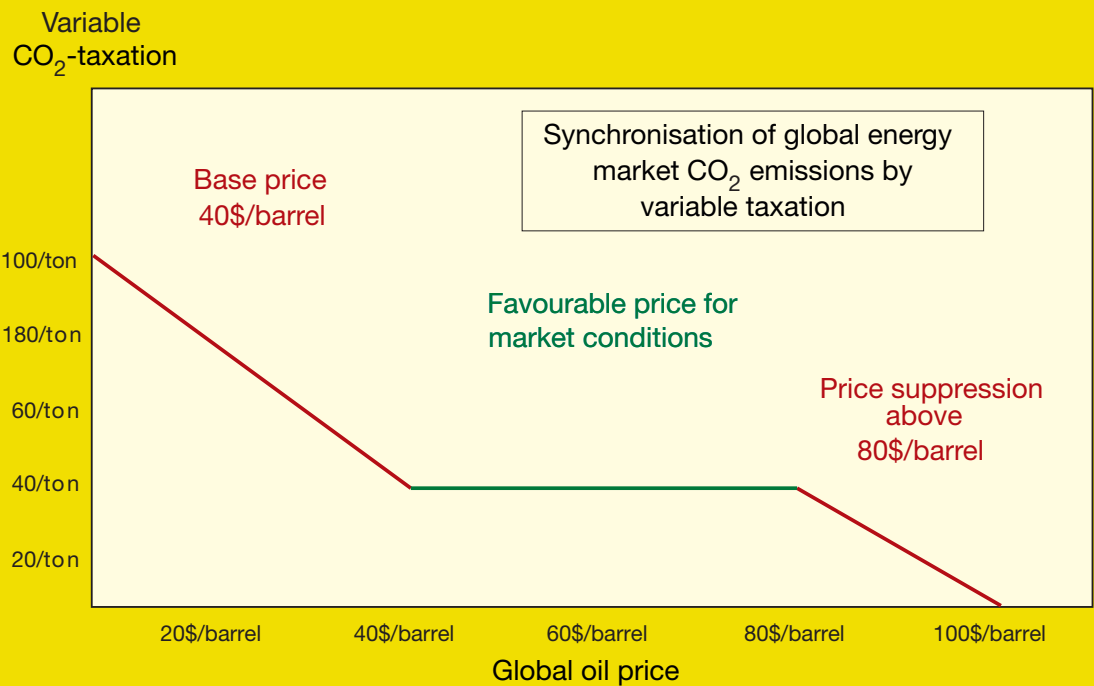
Unfortunately, market introduction is surrounded by uncertainty. The automotive industry has clearly stated that it is only prepared to develop fuel cell cars if it is certain that they can reach the mass market. ECN has organised a workshop in order to further explore the subject together with the industry. The automotive industry considers the government to be the most important "early market", but it is still unclear whether the government can function as such. The industry still seems to have little understanding of step-by-step penetration of

Effects on greenhouse gas emissions [Mton CO₂ eq]



The options for reducing greenhouse gas emissions by 2020 were examined in the Options Document study. It appears that emissions can be reduced by 25 percent compared to the 1990 levels, but this will require implementing many different options.

Transition policy has succeeded in creating a broad basis among industry, in research and in social organisations, but this has come at the expense of making clear choices about the desirability of concrete projects, new policy instruments and necessary financial resources. Contemplation on international insecurities would also be desirable. This is the conclusion drawn by Prof. J.J.C. Bruggink in his inaugural lecture on 21 November 2006 at the VU University of Amsterdam, where he was named endowed Professor of Energy Transitions and Sustainable Development at the Faculty of Earth and Life Sciences. His appointment is a result of the collaboration between the VU University and the Policy Studies unit where Bruggink works and has provided leadership for years. He proposes an integral price policy to gain synergy between international energy market developments and the CO₂ emissions market.



markets that offer slightly less protection. Both ECN and an industrial partner have warned for the so-called "Valley of Death", where an innovation can disappear after a successful preliminary introduction phase.

The public shows considerable interest for capture and storage of CO₂, resulting in increased policy activities in this area. The unit has earned an important advisory position in the EC, and is primarily oriented toward economic aspects, stimuli to construct a CO₂ infrastructure, regulation, and acceptance issues. In the context of international climate policy, the costs and benefits of greenhouse gas reduction have been studied, as well as possibilities for international agreements in developing new technologies, and their potential to reduce greenhouse gas emissions in developing countries.

The Ministry of Economic Affairs commissioned a follow-up study on the consequences of passing on the CO₂ price to the price of electricity. This research showed that electricity companies continue to charge the CO₂ price on their customers.



How are new energy technologies received by society and which factors influence how people accept and utilise these technologies? These are the central questions of the research that the Policy Studies unit begun in January 2006 with respect to the evaluation and promotion of social acceptance of energy technologies. The purpose of the research was to develop an instrument that could facilitate the process of social acceptance of concrete projects.

At the end of 2006, ECN was selected by the European Directorate General for the Environment to perform a similar study at the European level. In addition, ECN has advised the Dutch government regarding approval of CO₂ allowances in the future.

Other research subjects in energy markets involve the opportunities and barriers in the gas and electricity infrastructure. One of the questions raised about electricity is in what way can the increase in sustainably generated electricity be taken into consideration in the construction of active grids, and how can grid administrators sufficiently innovate to deal with it. The need for investments in the liberalisation of the gas market in the European gas infrastructure in different scenarios of demand developments has also been studied.

Methods for stimulating sustainable energy were put on the political agenda when the Dutch Minister of Economic Affairs Joop Wijn discontinued the Environmental quality of Electricity Production (MEP) programme in the fall of 2006. At the time, ECN was involved in a study of caps on MEP. Policy

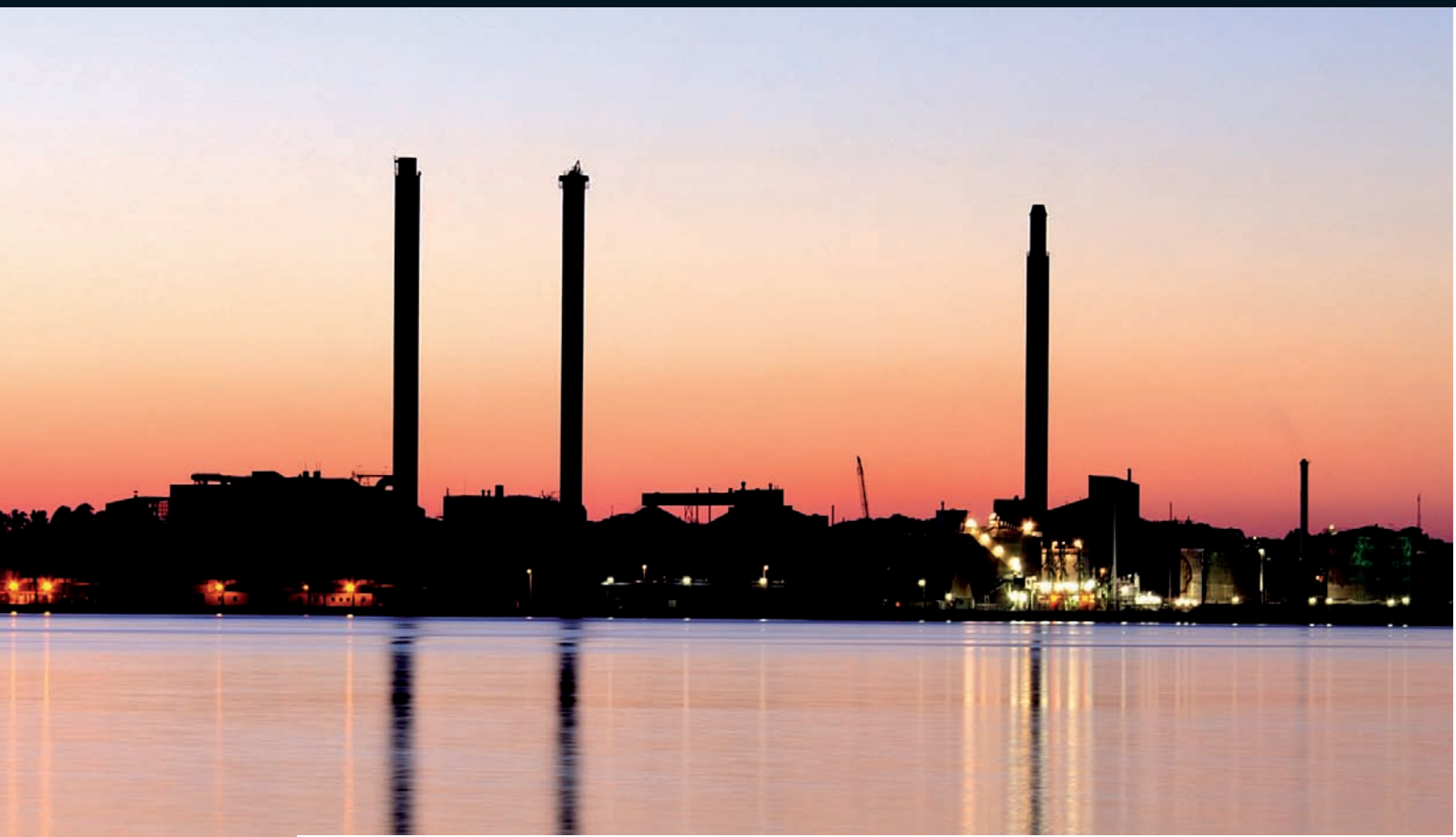
Studies advised the Ministry of Economic Affairs to make MEP more intelligent, partially by maintaining the existing system with an annual cap, partially by tendering and in the long term to work towards a hybrid system with obligations and extra price incentives for specific techniques. Our unit provided support to the Ministry of Economic Affairs when they were dealing with the MEP issue in the House of Representatives.

Remko Ybema can look back on a year in which his unit increasingly found its way to the spotlights. He is especially satisfied with the increase in assignments from the European Commission. "We are doing more policy support work for Brussels, especially for DG TREN and DG Environment. The European Commission is now as important a client as the Dutch Government; that was one of the goals of our strategy of the past few years."

Remko Ybema

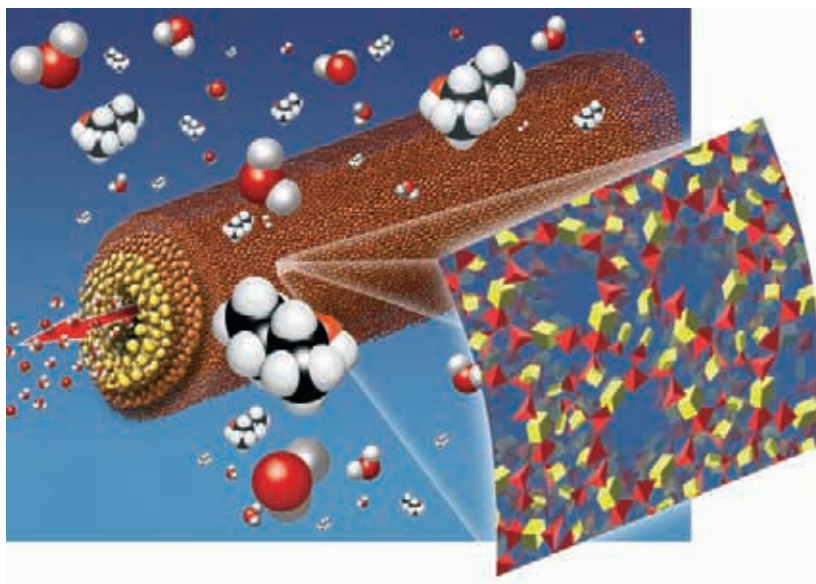


Remko Ybema



“In all of our work areas we noticed that the industry’s sense of urgency increased in 2006. The connection of energy efficiency and sustainability with innovation and new technologies is now clearly within view of the industry. This is unbelievably important for acceptance of our work.” Energy Efficiency in Industry unit manager **Peter Alderliesten** is pleased with the perspective of more intensive co-operation with producers and users of process equipment, the foundations for which were laid in 2006.

One of the signs of intensifying co-operation with the market is the foundation of the Dutch Separation Technology Institute (DSTI), a virtual institute where the collected universities and research institutes work together with the industry. The unit provided an important contribution to building the institute. We expect DSTI to provide even more industrial focus in our spearhead molecular separation technology, because ECN participates in a number of projects for the energy-intensive sectors of bulk chemicals, oil and gas.



Impression of a hybrid membrane, with a schematic detail of the separating layer.

In this field the newly developed hybrid silica membrane for dehydration seems very promising, as it has passed the first endurance test at a temperature of 150°C with flying colours. Its flux and selectivity are sufficient for a cost-effective application. Industrial users are very interested in the possibilities offered by this type of membrane.

Work on ammonia and oxygen separation is still in progress. In both cases, we have not yet developed a membrane that meets the demands for flux and selectivity. For successful oxygen separation, there is even a greater challenge; finding a quality seal that can function at the high process temperatures which are characteristic for this type of membranes.

For the second spearhead, multi-functional reactors, Peter Alderliesten sees a similar development in the market: active interest from the industry (manufacturers and end users). The subject of multifunctional reactors is one of the issues of the transition path Process Intensification (PI), which is strongly advocated by the Platform Chain Efficiency. It was decided to draw up a road map. In order to achieve that, a "Process intensification action group" has been formed under the guidance of the former Director of Technology at DSM, in

co-operation with Delft University of Technology, SenterNovem and ECN. The core of the recommendation is that consortia should be formed between research institutes and the industry for specific topics, to exploit promising parts of the transition path. Further, it was recommended to join forces with German partners for the road mapping process. This has since been realised. The group is strongly supported by the national process industries. "We join hands and intend on entering the European market together", says Alderliesten.

In the field of multifunctional reactors ECN is already working in a consortium on the hydrogen membrane reactor. In this reactor, the chemical conversion of methane and separation of the produced hydrogen are combined. By expanding the consortium with partners active in the market for small reformers, we can cover the entire hydrogen market, from large to small scale applications. Further, a European project for propane hydrogenation based on hydrogen-selective membranes (with co-operation from Shell, Westfalia Separator and Cereco, among others) was technically successful, although the feasibility studies showed that the membranes' performance needs to be improved in order to get economically feasible processes. In the meantime, we are actively involved in the choice of

Energy Efficiency in Industry



SOCOOL sorption cooling machine at Fiat-CRF.



Membrane test installation for ammonia separation in Tertre (BE).

priorities for a second technology line. Co-operation with Delft University of Technology in bringing their structured reactors to the market seems to be an attractive option.

In the spearhead industrial heat technology, the work on industrial heat pumps also scores well due to a dramatically increased interest from the market. In co-operation with parties from several industries (each with processes consuming large amounts of heat while also producing considerable amounts of waste heat), we have worked out a number of business cases for industrial heat pumps. Based on the performance requirements set for the thermo-acoustic and thermo-chemical heat pumps currently under development concrete and economically attractive projects are possible. Industrial partners are enthusiastic about participating in further research. The results of these studies enabled us to approach new partners for research and development, both in the equipment manufacturing and end use sectors. Five companies have shown great interest in further co-operation. This may form a sturdy foundation for further consortium-formation and market-oriented development of heat pumps.

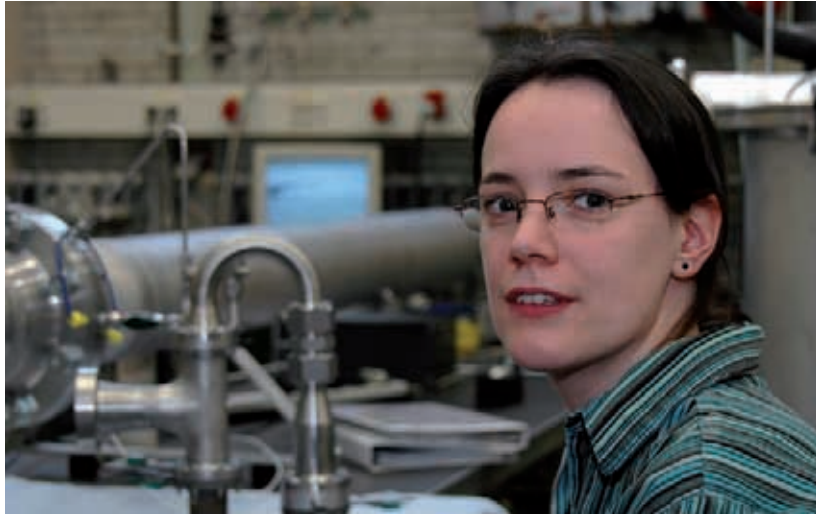
Increased interest from industry is also illustrated by the reactions we got while executing a project for ROM-Rijnmond regarding the so-called Botlek loop for industrial heat exchange. We have worked

out business cases for two neighbouring companies in which cooling for one party is generated with residual heat from the other one via sorption technology. The results were enthusiastically received in the Synergy in Energy workshop held at the end of June in Rotterdam.

The SOCOCOL project, where this sorption technology was developed, concluded with great success. A sorption cooler developed by ECN based on silica gel was demonstrated by Fiat-CRF. The cooling performance satisfied their expectations. Fiat-CRF is interested in further development of the technology, and ECN will be directly involved as it has the most expertise in this cooling technology. SOCOCOL has been followed by TOPMACS, with the goal of improving heat transfer, reducing volume and weight, and simplification of system management. The intention is to make mobile applications for cars and trucks possible.

Developments in thermo-acoustic heat pumps were very successful in 2006; both efficiency and temperature lift were significantly improved. There seem to be no more conceptual hindrances for developing equipment for the market.

The original reactor concept for the thermo-chemical heat pump turned out to be too heavy and expensive, and was adjusted after discussions with the industrial partner. The sorption composite, however, appeared to function well in the test situation.



Post doc Gaelle Poignand with an experimental thermo acoustic heat pump.

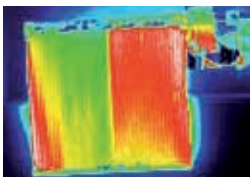
Industrial heat pumps have great potential for energy savings in separation processes, particularly in distillation. This has led to an approved proposal within DSTI, in which various applications will be developed in co-operation with industrial partners.

Peter Alderliesten can look back at a year with many new perspectives. “Our philosophy that energy efficiency and sustainability should be coupled to technological innovation is now widely accepted. Our field is sown, the fruits are ripe and now we can begin to harvest.”

Peter Alderliesten

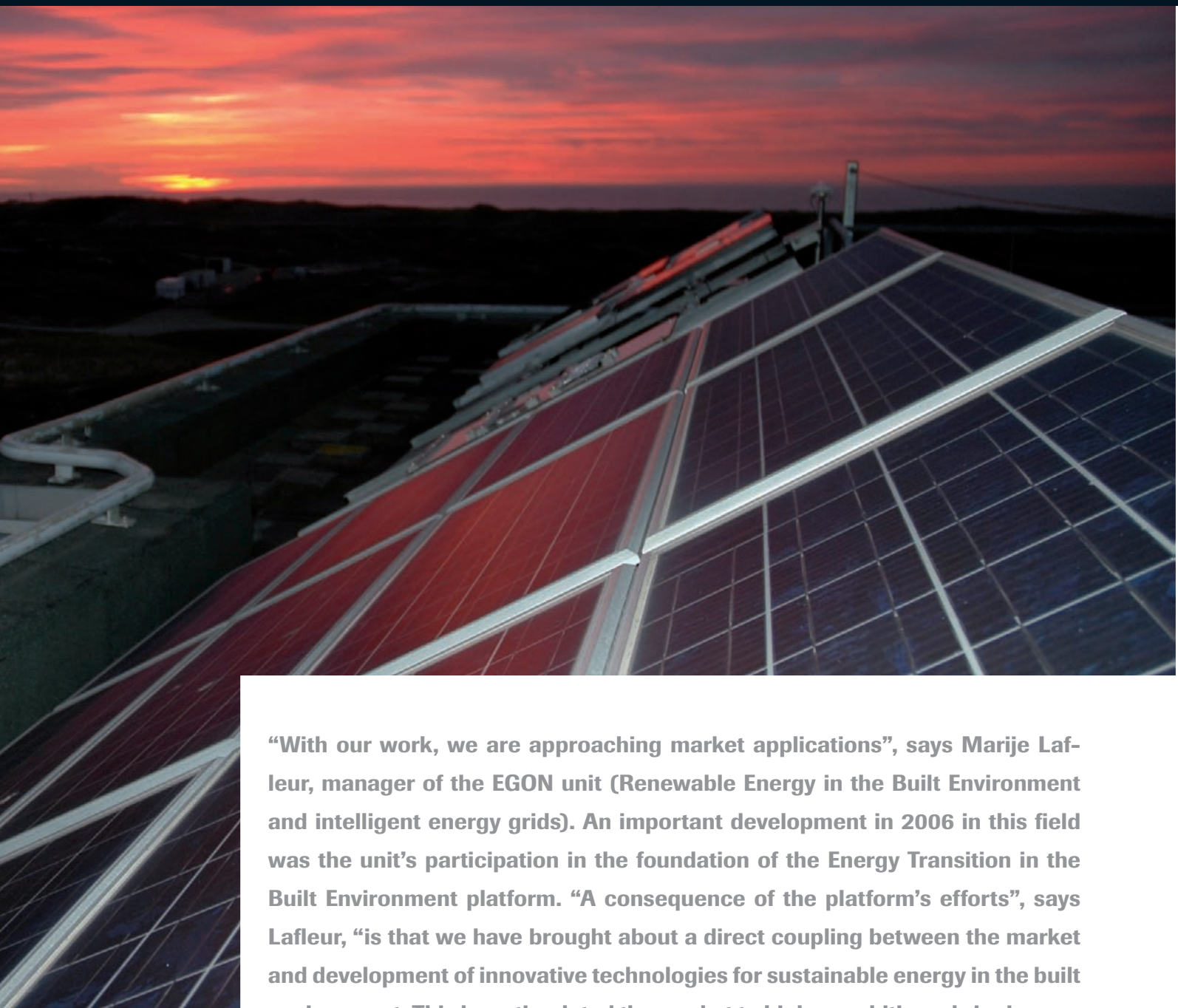


Peter Alderliesten



Compact heat exchanger (right) and an image taken with a thermal camera of the temperature profile during use as a sorption reactor.





“With our work, we are approaching market applications”, says Marije Lafleur, manager of the EGON unit (Renewable Energy in the Built Environment and intelligent energy grids). An important development in 2006 in this field was the unit’s participation in the foundation of the Energy Transition in the Built Environment platform. “A consequence of the platform’s efforts”, says Lafleur, “is that we have brought about a direct coupling between the market and development of innovative technologies for sustainable energy in the built environment. This has stimulated the market to higher ambitions, bringing applications of these new technologies to the foreground.”

Previous developments in the field of ‘gas fired absorption pumps’ for residences failed due to the size of the machinery. This seems to be changing now. ECN has developed a working prototype that is compact enough to be fitted to a wall, just like a gas furnace. After successfully testing a space-heating unit in a pilot residence for a longer period, we have performed subsequent studies on its qualities as a space-cooling unit. To do so, we converted the heat pump to an air-air (source exchange) system. These measurements have provided insight into energy production and given us ideas for pos-

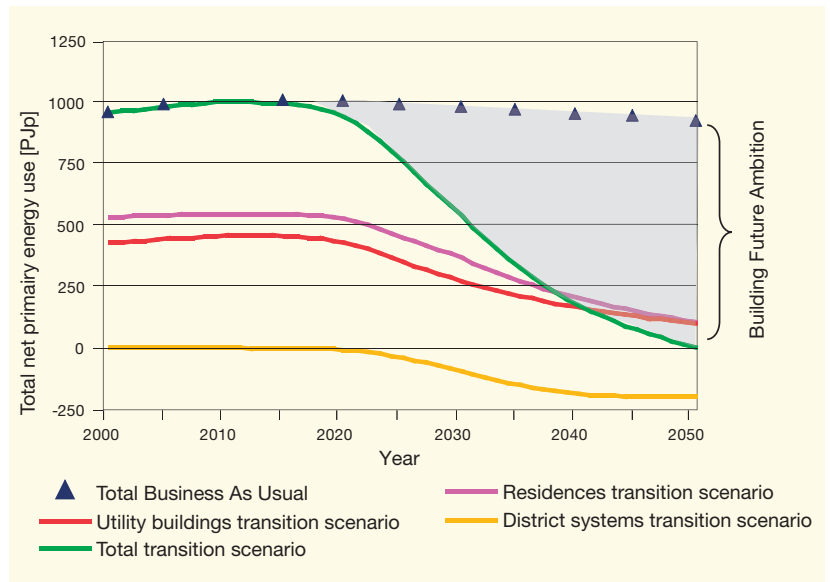
sible improvements. The client is now prepared to take a step towards a large-scale field test in actual homes.

One of the unit's important trump cards is the pilot residences including the rotating test house, in which the influence of a building's orientation in relation to the sun on its energy consumption can be studied. A large new test façade has recently been installed in this house in the context of the Zon-WEL project. These facades are equipped with local climate control measures, including heating, cooling and ventilation through installations integrated in the façade. This specially developed climate control system also has a unique reversible heat pump and a balance ventilation unit with vapour retrieval, also called an enthalpy exchange, integrated into the façade.

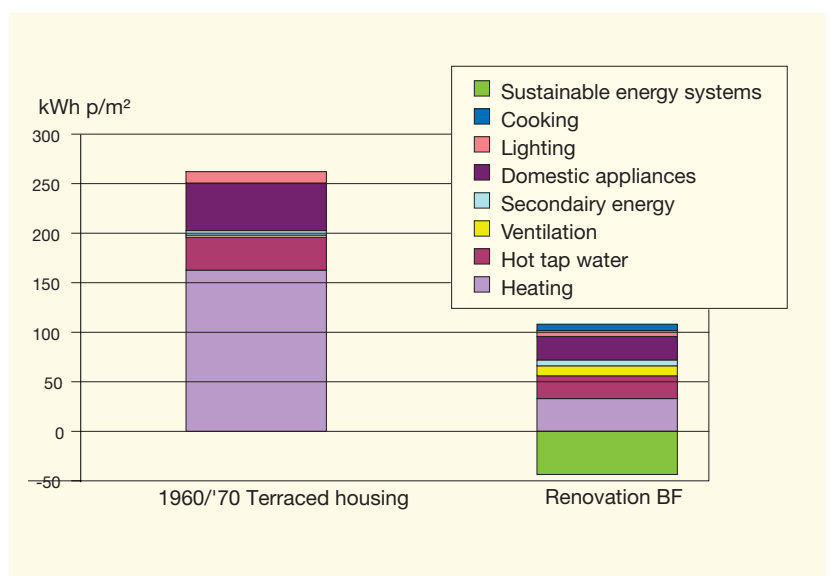
In the new residential project 'Stad van de Zon' (City of the Sun) in Heerhugowaard, together with TNO, the unit administers a measurement and demonstration house under the name of ISOzero. The unit has conducted successful measurements of an innovative heat-pump system in this residence. A remarkable discovery was that compartmentalisation of the residence offers many advantages, both for structural engineering as well as for installation technology; it enables the house to better satisfy temporary demands for heating and cooling.

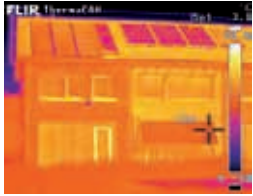
Passive Construction is an important concept in energy-efficient housing design. The unit contributes to this idea in various ways. For example, in the Promotion of European Passive Houses (PEP) project, this concept was subject to demands for the various climate zones at the European level. Under the direction of ECN, agreements were hammered out about a European-wide standard for passive house certification. PEP also provided input for the new Foundation for Passive Construction that aims to promote application of this concept in the Netherlands.

The Government Buildings Agency of the Netherlands Ministry of Housing, Spatial Planning and the Environment uses PVT panels developed by ECN to utilise an innovative energy concept for generating heat and electricity from the sun in a government office building.



In a scenario study, we have also explored how energy use in the total built environment is expected to develop ('business as usual'). In order to reach the ambitious Building Future target of energy neutrality by the middle of this century, we will need new target figures for new construction and adjustments to existing structures. It seems that complete system innovations are not only necessary for household appliances and individual buildings, but for entire neighbourhoods. After an economic evaluation of the various options, we have





Infrared photograph of residence A

developed and expanded a few potentially attainable building concepts for a few market segments.

We have also performed other system studies regarding opportunities and risks for solar cell systems in the built environment, and regarding demand side management in residences and other buildings. The last study indicated that energy profit could be attained by guiding energy management in buildings through performance monitoring; residential buildings have a significant potential for regulators that adapt to the user (and perhaps send information back to the system).

Thermal systems form a special field of interest for the unit. Among other projects, we are working on thermochemical storage and storage with phase change materials. In the first case, heat is stored in chemical form through materials such as magnesium sulphate, which releases water when heating and releases heat when bonding with water; the research is oriented towards exploring the characteristics of such thermochemical materials. In the second instance, heat is stored through a phase conversion, such as melting. Heat storage using such materials can occur in a much more compact space than with perceptible heat.

Compact heat storage in a test environment.



Compact heat storage as being built. Plates and cover have to be finished.



GasTerra has shown interest in this process for developing instruments for heat storage in combination with a micro-heating power unit. With sufficient heat storage, the unit's electricity production can be disconnected from the heating demand, which will assist its success in the market. As heat storage usually occurs in a limited space available in existing residences, the market demands a very compact system.

Solar-thermal systems form another point of interest. Marije Lafleur, describing the developments in 2006: "The foundation of the European Solar Thermal Technology Platform, in which European researchers and industries active in the field of heating are brought together, was an event of international importance. ECN was directly involved as the chair of the working group in the field of storage, and co-chair of a working group specifically geared to reviewing the necessary developments of solar-thermal systems in building renovations."

Our own research, in co-operation with TNO and other parties, is primarily geared toward the long term: exploring construction systems, architecture and chemistry (the latter in connection with heat storage). Two workshops produced sketches of future solar collectors with the characteristics: flexible, intelligent, modular, energetically independent and integrated in the structural engineering construction.

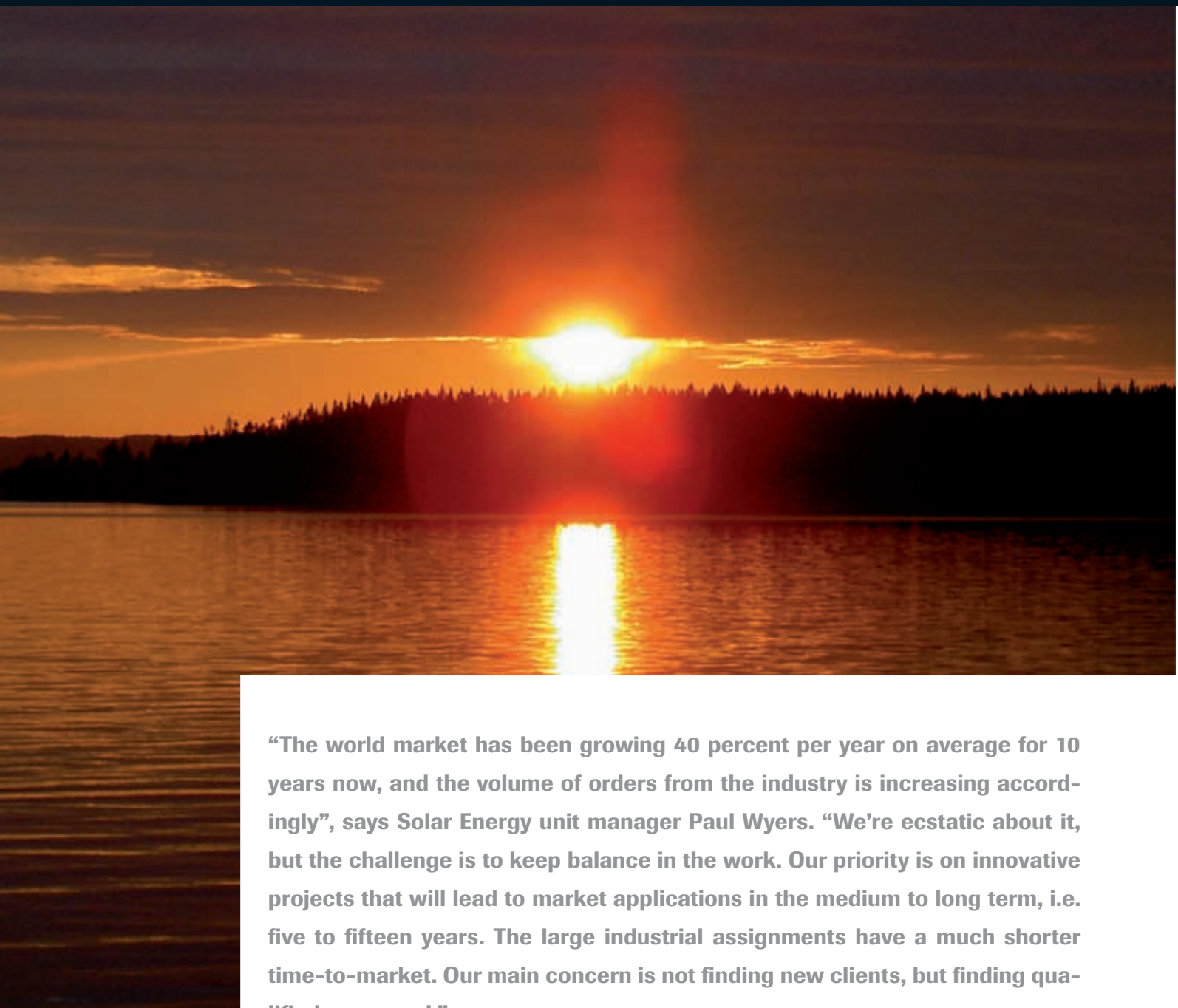
The EGON unit also performed work on micro-heating installations. At the request of ENATEC, we are working on two research lines for realising a system based on a Stirling motor.

The first line of research is directed towards improving the price/performance ratio of the Stirling, in co-operation with the Japanese firm Rinnai, in order to bring it to a level that makes it useful for the mass market. Work on the motor is progressing well, and should be introduced to the market in 2007. The second line of research is devoted to developing a micro heat-power device suitable for the European market. In this project, we are co-operating with Merloni Thermosanitari, an Italian boilermaker with the fifth largest volume in Europe.

Marije Lafleur



Marije Lafleur



“The world market has been growing 40 percent per year on average for 10 years now, and the volume of orders from the industry is increasing accordingly”, says Solar Energy unit manager Paul Wyers. “We’re ecstatic about it, but the challenge is to keep balance in the work. Our priority is on innovative projects that will lead to market applications in the medium to long term, i.e. five to fifteen years. The large industrial assignments have a much shorter time-to-market. Our main concern is not finding new clients, but finding qualified personnel.”

In 2006, research in crystalline silicon solar cells progressed on all fronts. Producing a working photovoltaic (PV) system requires very pure silicon processed into thin wafers; these are then made into solar cells and connected to each other in a module. The unit develops technology in all of these areas and has been successful in each one.

Silicon

We have achieved a top efficiency of 17.4 percent with a 160 μm thin cell made with a simple screen printing process based on monocrystalline n-type silicon. By making it possible to use n-type silicon instead of the usual p-type, we have pioneered a source of silicon not utilised until now. By using this source, the current global shortage of silicon could be reduced. This n-type silicon also makes cell performance less sensitive to impurities and defects, which also has advantages in the long term. In conjunction with Utrecht University, we are developing techniques to make solar cells from n-type (crystalline) silicon wafers by making the emitter through deposition of a thin layer of amorphous silicon in a vacuum.

Wafers

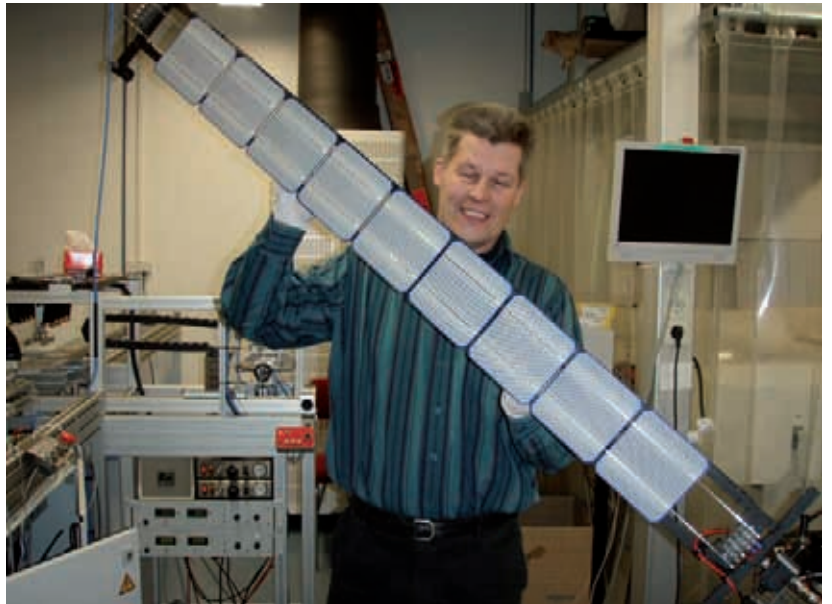
ECN is also leading research in direct casting of silicon wafers without sawing, the so-called RGS wafers or ribbons (RGS ; Ribbon Growth on Substrate). Average cell efficiency from wafers produced by this process rose from 8 percent to 12 percent, and the peak efficiency now exceeds 14 percent. This technology, well suited for making thin wafers, has allowed a record low silicon use of 3 grams per watt-peak of solar cell output. This figure should be compared to the 10 grams per watt now common for the thicker, sawed wafers produced commercially.

Cell fabrication

We have also achieved significant efficiency improvements in cell fabrication. One module made of 36 cells measuring 156 cm^2 achieved an encapsulated cell efficiency of 14.8 percent, close to the official world record of 15.3 percent attained with a much smaller module. New research is geared towards producing even thinner cells. This fabrication process allows considerably lower cell breakage percentages.

Module fabrication

We are currently perfecting fabrication methods of PUM cells, the only integrated crystalline silicon cell and module concept now available, with a higher output at the module level. PUM modules have proven to allow 4 percent higher output than conventional modules that are otherwise identical, at almost no extra cost. The main advantage of



A cell-string made with the new tabber-stringer pilot line.

this technology is the large potential for improvement of the cost-performance ratio, because this enables the use of very thin cells without increasing cell breakage. Further developments are geared towards finding an electrically conductive glue to replace lead solder, and researching connecting materials that will allow lower mechanical stress in the modules. The industry has shown great interest in this module-related research.

Another important line of research involves thin-film solar cells. Paul Wyers: "In June, ECN and the German instrument manufacturer Roth & Rau installed a system for depositing thin-film silicon on foil. This system will allow ECN to develop a fabrication process for thin-film microcrystalline silicon solar cells and microcrystalline silicon/amorphous silicon tandem solar cells."

In 2006, we moved into new laboratory facilities for producing polymer solar cells. These cells promise very low fabrication costs and new application possibilities over the long term. This new fabrication line allows some of the highest efficiency levels in the world. Spectroscopic measurements combined with optical models have provided new insights into this type of solar cell's working principles and loss factors.



Picture left and below:
Prototype plasma deposition
machine for producing thin
film silicon solar cells on foil.



Another future concept is the dye-sensitised solar cell, which may also offer lower costs. The critical success factor for this type of solar cell is that it must remain hermetically sealed under outdoor conditions. New techniques for thermoplastic sealing allowed cells that had been exposed to normal outdoor conditions for three months to continue to produce at 93 percent of their original output. ECN

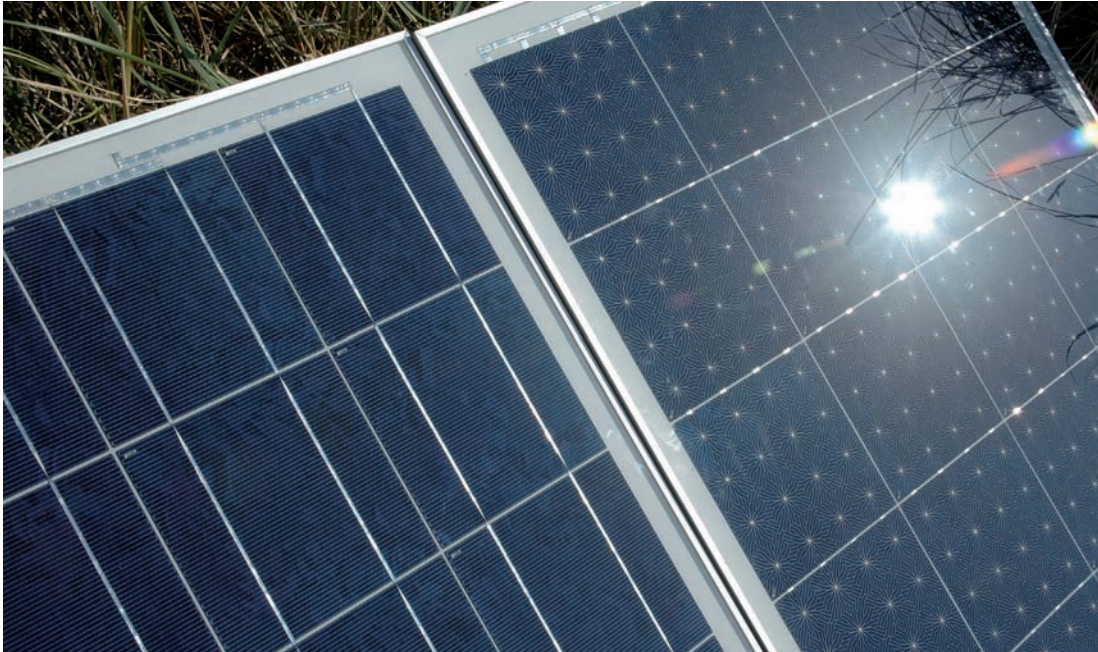
and Shell are working on a new solid-state variant of the dye-sensitised solar cell, which usually contains a liquid electrolyte. In 2006, we made important progress in developing fabrication methods for this type of cell.

Our last line of research involves fundamental increases in solar cell efficiency by using a larger part of the solar spectrum. This will be made possible by developing a luminescent concentrator in which visible light can be concentrated on a narrow fringe using luminescent dye molecules and fully internal reflection. A new computer model also provides insights into factors that may lead to efficiency loss. New and more stable dyes should help increase efficiency further. The industry is also interested in this more fundamental line of research.



The first Pin-Up cell with a
silicon nitride coating on both
sides.

Paul Wyers: "A better co-ordination of the research and applications in Europe would be beneficial for our work. We are therefore very pleased with the foundation of the EU Photovoltaic Technology Platform, in which all of the important parties in the field of solar energy work together. Our unit is



Two modules, one with H-patron cells, the other with PUM cells. Both solar cells and panels are produced with identical process parameters. The H-patron module supplies 122.8Wp while the PUM module shows an increase of 4.4 percent resulting in 128.2Wp.



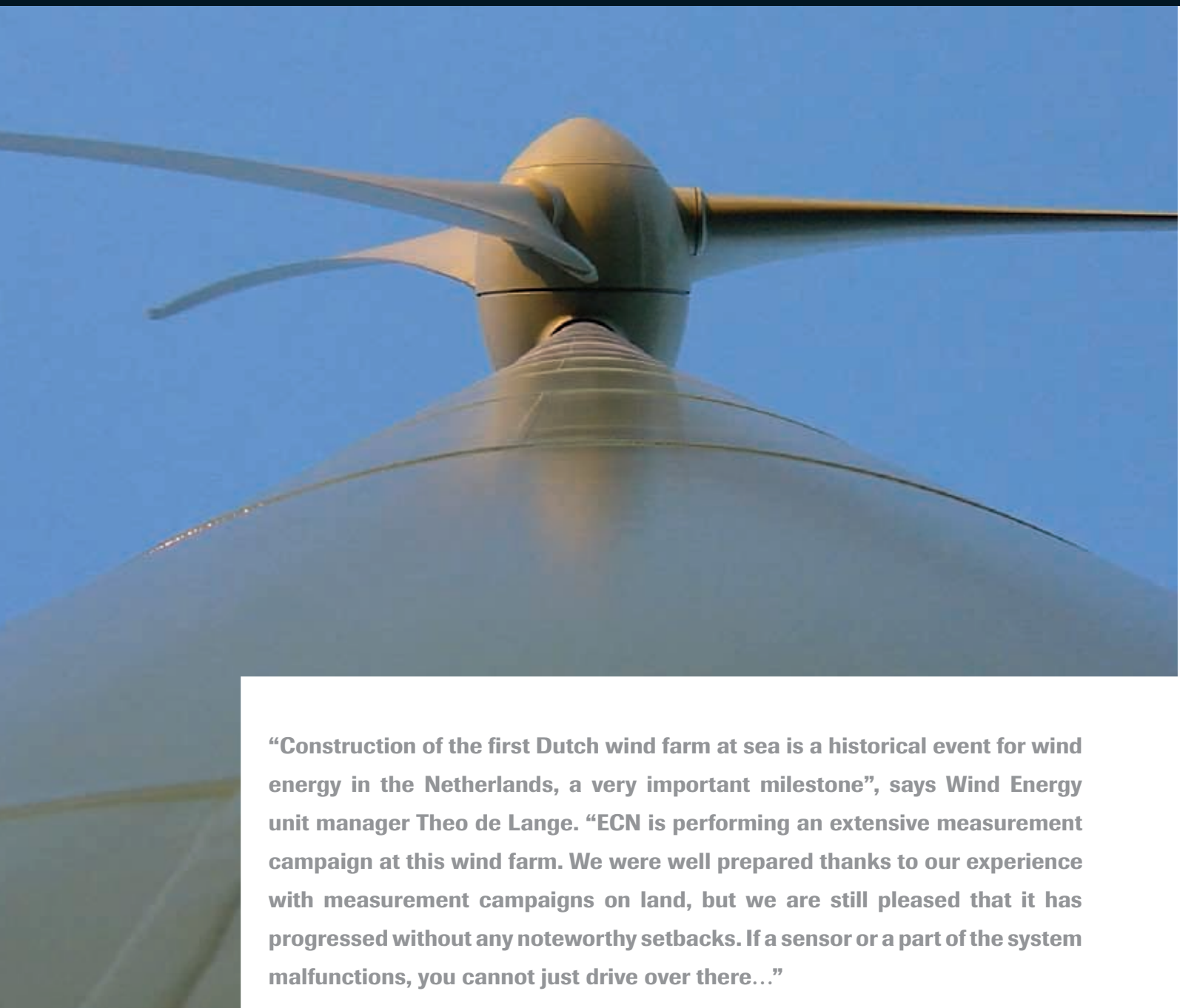
represented in the steering committee. One of the platform's first tasks was to draw up a strategic research agenda. This should give PV research in Europe more focus and enable national and European efforts to reinforce each other."

Paul Wyers



Paul Wyers

TV-recordings for the Dutch programme Netwerk.



“Construction of the first Dutch wind farm at sea is a historical event for wind energy in the Netherlands, a very important milestone”, says Wind Energy unit manager Theo de Lange. “ECN is performing an extensive measurement campaign at this wind farm. We were well prepared thanks to our experience with measurement campaigns on land, but we are still pleased that it has progressed without any noteworthy setbacks. If a sensor or a part of the system malfunctions, you cannot just drive over there...”

“At the same time, we have begun a measurement campaign for the Down-Wind project. In this project, two 5 MW turbines were placed off the coast of Scotland in 40 meter deep water. ECN performs a number of measurements in order to eventually validate the design calculations.”

The Dutch Wind R&D Workshops held in 2006 were very successful. These workshops were organised at the initiative of ECN together with Delft University of Technology, the Knowledge Centre for Wind turbine Materials & Constructions WMC and SenterNovem. For two days, researchers from these organisations presented all R&D activities in the field of wind energy in the Netherlands to an international audience from the wind energy industry. The international top-5 wind turbine and blade manufacturers were among the 150 guests present. These workshops led to more assignments for all three institutes. In the course of the presentations, the idea that the Netherlands is an important player in the field of wind energy R&D was reinforced, and that this role will increase as there is a structural shortage of well-educated researchers and engineers. Turbine builders' R&D departments will therefore increasingly be forced to hire extra R&D capacity from international research institutes. We have already begun to notice this due to the increased number of industrial commissions.

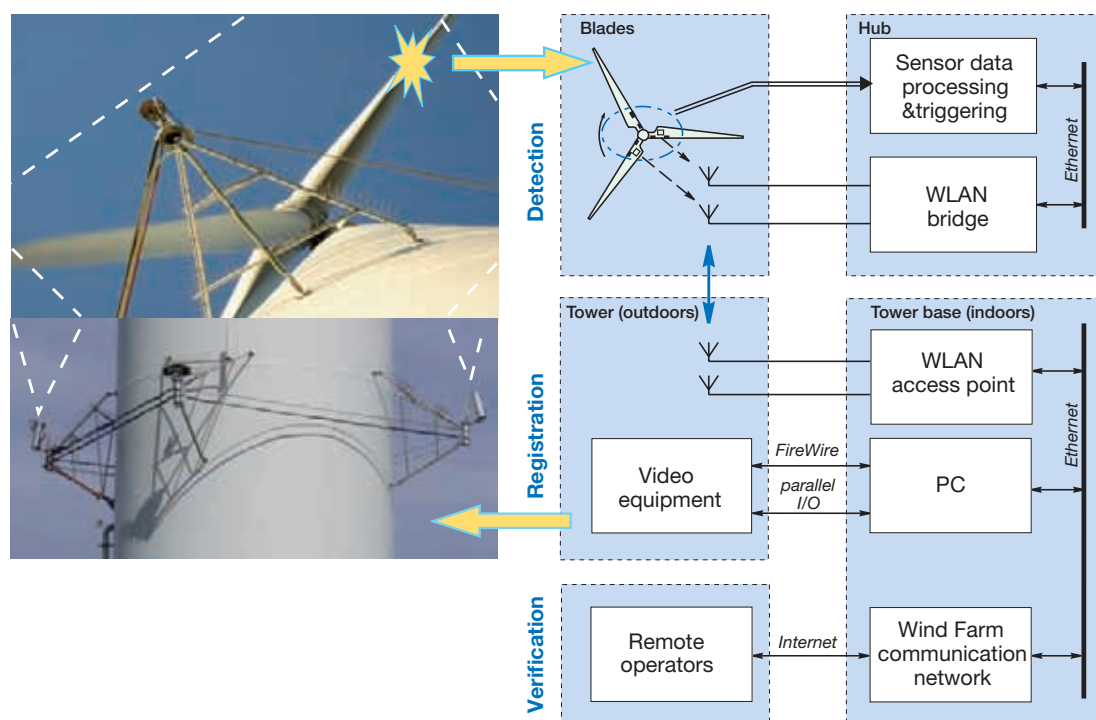
This reinforced position for Dutch wind research seems to be the fruit of years of consistent efforts. The three leading institutes, WMC, Delft University

of Technology and ECN, complement each other and work well together. Their research is well led and supported by the EOS-LT research programme, executed by SenterNovem. In the short and intermediate term, the We@Sea consortium will also play an important role.

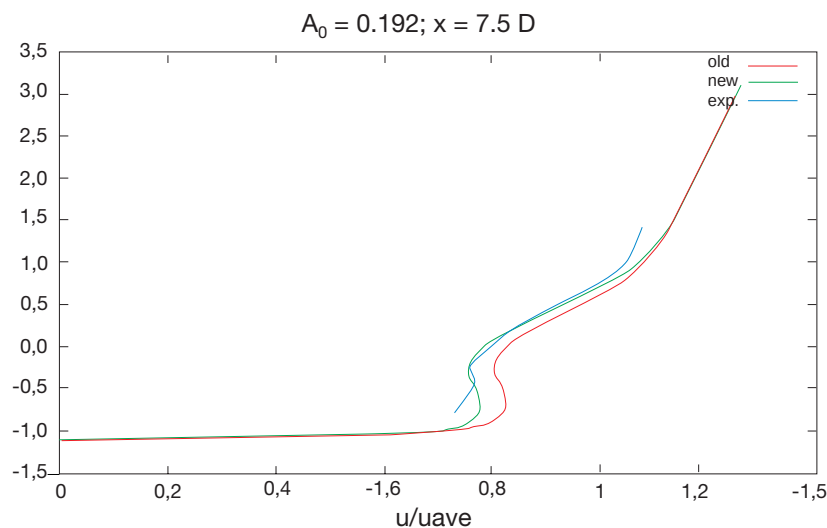
Theo de Lange: "This has been noticed by the EU; the research approach in the Netherlands was praised in the recently published report The State and Prospects of European Energy Research. Together with Germany and Denmark, the Netherlands lead the field of research and is second only to Germany in terms of the amount spent on research in the period 2000 - 2004 (approx. € 10 million per year). In short: our perspectives for the coming years are outstanding!"

We have achieved significant results with measurements on a scale model of a wind turbine with a rotor diameter of approximately 4.5 metres in the large German-Dutch wind tunnel. These measurements have produced a treasure trove of information. We have also observed some phenomena that had not been seen before. These measurements will be used to draw up and validate design models.

Overview WT-Bird



The WAKEFARM model is used to compute the wake behind a wind turbine, i.e. the velocity components and turbulence characteristics. Due to the limitations of the model, the near wake is excluded from the analysis and computations are started at some distance behind the turbine. This means that the physics directly behind the turbine are not modelled properly. In an attempt to improve the physical modelling of the near wake, an analogy with the so-called boundary-layer equations is made. This enables the near wake to be included in the analysis. The behaviour of the model is shown in this figure. A velocity profile in the vertical direction and in the symmetry plane at 7.5 rotor diameters behind the turbine is compared with wind tunnel data. The original model (labelled 'old') and the modified model (labelled 'new') are compared with experiments (labelled 'exp'). For this case, an improvement of correlation with the experimental data is observed. It may be concluded that the near wake is important for the far wake results.



The results of the old model and the adapted model (including the near wake effects) compared with measured values.

The unit's research programme is characterised by five main research areas. We have achieved progress in all of them.

Rotor Aerodynamics

The development of a new aerodynamic model, Rotorflow, is progressing on schedule and the preliminary results look promising. The measurements on the scale model in the German-Dutch wind tunnel mentioned above are very important for developing this research priority.

Wind Farm Aerodynamics

In 2006, we added models for near wake to the wake model. In addition, the unit has taken an important step towards validating wake models and farm control strategies. In 2006, we also decided to commence construction of a new experimental facility: an addition to the EWTW test field in the Wieringermeer with eleven small turbines (rotor diameter of 7 metres) and an extensive measurement infrastructure. This will allow us to gather high-quality data to apply in developing and validating

aerodynamic models and farm control strategies for wind farms. The farm may also be used to perform measurements of rotor aerodynamics and advanced turbine controls.

Wind Turbine Control

One important instrument for this is the computer model Turbu, which can simulate the interaction between wind, sea and the aero-elastic behaviour of the wind turbine and wind turbine components due to control actions. Development of this model and its control tool is progressing well and has attracted much attention from the industry. The initial validation of Turbu will be performed in conjunction with Siemens, which has also shown interest in further co-operation with ECN in this field.

O&M Models

Analysis of operational data of the Nordex N80 turbines in the EWTW indicates that the mechanical load varies widely per turbine, causing in turn large variations in the maintenance needed per turbine. The goal of the model development is to



use maintenance and operational data of a wind farm, combined with limited quantities of measurement data, to estimate the maintenance required for all turbines in the wind farm in the near future. The unit will intensify its research in this matter in the coming years based on the 'Operation and Maintenance Cost Estimator' model developed here at ECN.

Condition Monitoring systems & Measurement Techniques

Analysis of the preliminary results for the bird collision detection system WT-Bird has led to a number of adjustments and improvements to its configuration and detection algorithm. The system has been running on one of the Nordex N80 turbines in the ECN test field without any problems since March. The first commercial application is expected in 2007.

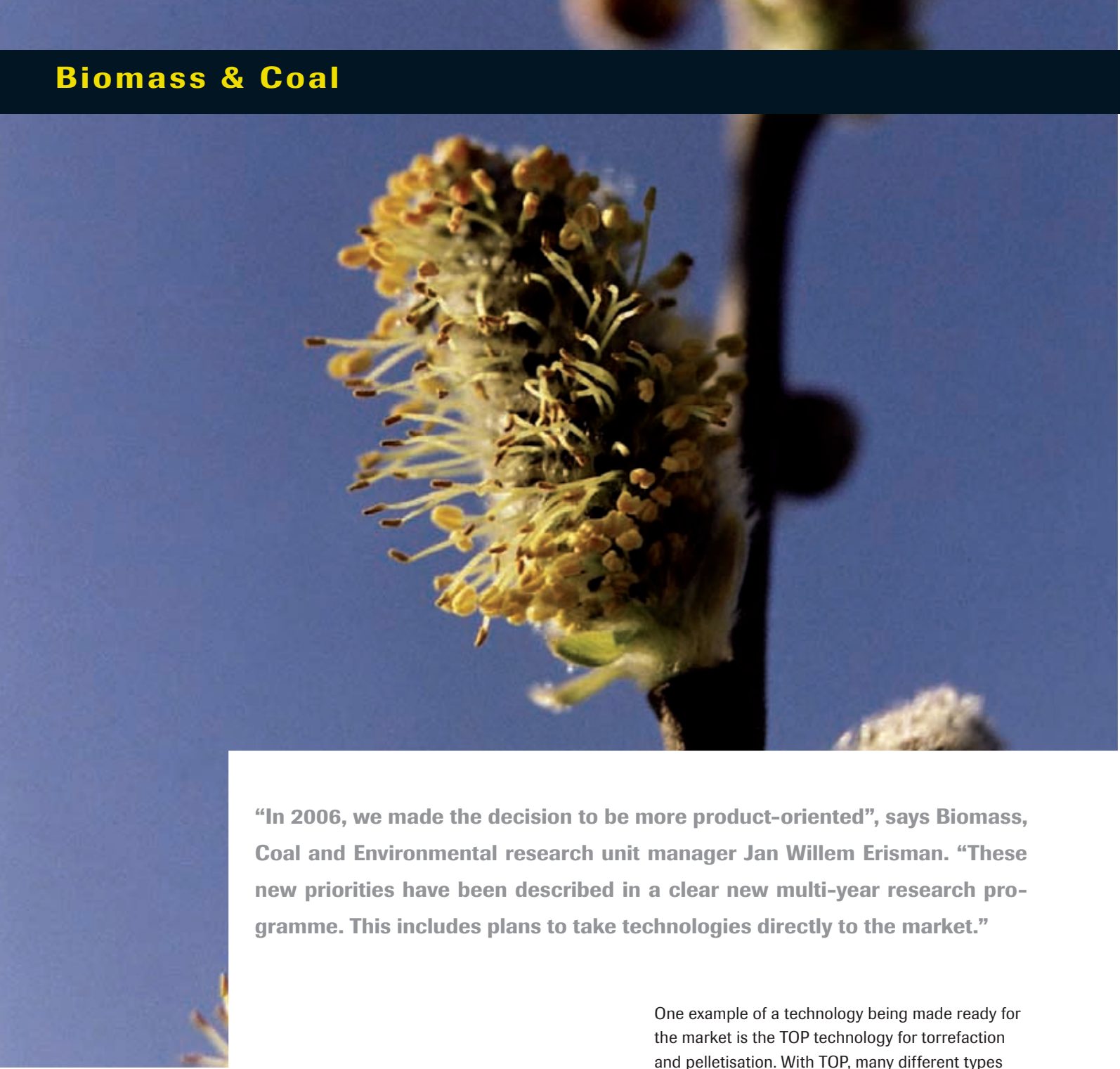
Theo de Lange also looks to the future: "One breakthrough was the decision to build a small-scale wind farm for farm measurements on the same

location as the large test field in the Wieringermeer. Eleven small turbines and sixteen measurement towers will be built. We will be able to test all sorts of control strategies, which will support our work enormously."

Theo de Lange



Theo de Lange



“In 2006, we made the decision to be more product-oriented”, says Biomass, Coal and Environmental research unit manager Jan Willem Erisman. “These new priorities have been described in a clear new multi-year research programme. This includes plans to take technologies directly to the market.”

One example of a technology being made ready for the market is the TOP technology for torrefaction and pelletisation. With TOP, many different types of biomass can be converted into a standard fuel with ideal characteristics that are well adapted to transport, storage, and conversion in combustion and gasification installations.

The technology is still in the development phase – we will open a 100 kg/hour pilot installation in 2007 and construction of one or more demonstration plants for 20 kton/year will begin in 2008 – but we have already received a lot of attention from the industry. Erisman: “Industries from around the world have come by to set up a demo with us. In order to accelerate the development and market the technology well, we have set up a knowledge corporation, BO2 energy concepts, which will start up a number of demos.”

Another commercially successful technology is the process for removing N_2O during nitric acid production by direct decomposition. We have decided to bring the applicable patents together in the company ToN2 BV in order to enable the broadest possible application of technology with the highest possible financial yield. After the successful test at DSM, the next step will be a full-scale demonstration. A number of parties have already come forward to participate in potential projects.

In December 2006 ECN and the Dortmund-based Uhde GmbH, a company in the Technologies segment of the ThyssenKrupp Group, signed a licensing agreement in the field of N_2O abatement in nitric acid plants. This agreement permits Uhde GmbH to employ ECN know-how throughout the world for the catalytic reduction of N_2O with hydrocarbons in Uhde's EnviNox® process. This Uhde EnviNox® process has been successfully implemented in the nitric acid plants for Abu Qir Fertilizer Company Egypt. These EnviNox® reduce N_2O and NO_x emissions by over 98 percent.

Many of our projects study the co-firing of biomass in coal-powered stations. The power stations in Borssele and Geertruidenberg are studying pollution and corrosion in heat exchangers; in Borssele this is done in co-operating with KEMA studying the composition of ashes to determine the effects of heavy metals; and we have built a database to predict the viscosity of various fuel compositions. The unit has also developed a probe to observe the behaviour of ashes inside the boiler, in order to better predict and prevent boiler pollution.

We have also co-operated with Delft University of Technology to develop a method for detecting and controlling agglomeration in fluidised beds, called EARS. The instrument is now so far developed that it can be applied in industrial installations. If these tests are successful, EARS can be brought to the market.

One of the unit's most important activities is gasification of biomass. Our patented technology MILENA will be scaled up to 0.8 MW after conclusion of the test period. At the end of 2006, we were able to run a seventy-hour period of successfully coupling gasification, gas purification and produc-

tion of SNG (Synthetic or Substitute Natural Gas). The methane gas produced contained very little CO or H_2 . Further work on SNG production will concentrate on making the catalytic converter more environmentally friendly. MILENA is being further refined together with the industrial partners HoSt and Dahlman. Many parties have expressed interest in speeding up development of this technology: energy companies, oil and gas producers, local and provincial governments, etcetera. A plan was made for a 10 MW demo heat power station, which will produce SNG in a slipstream. The goal is to have large-scale production of SNG by 2020. We have already received approval for construction of a pilot facility on the ECN grounds for further research.

Our long term test of the OLGA tar filtration technology situated after a 0.5 MW BIVKIN gasifier was successful, enabling tar-free gas to be fired in a gas motor in order to generate electricity. A larger-scale version of OLGA has also been successfully tested

Deposition probe mounted in exhaust pipe.

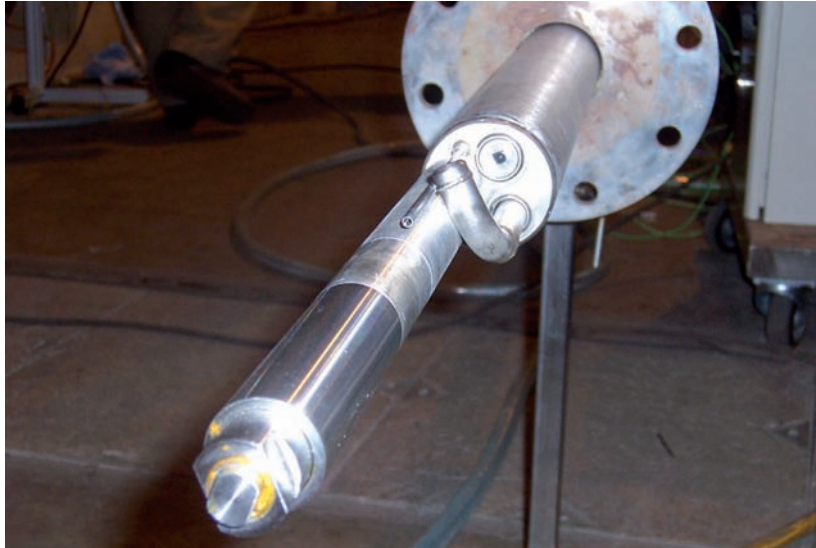




The 'Lab-scale Combustion Simulator' (LCS).

at Eneria in France. The French partner was so enthusiastic, that they have begun engineering an OLGA behind a 40 MW gasifier.

Biorefinery is a new area of interest. The test for staged degasification of beech wood in 2006 was a technical success, producing many valuable chemicals. In another project in co-operation with WUR-agrotechnology & food sciences group, willow wood was treated with enzymes in order to produce sugars from lignocellulose. This dealt with a so-called second generation technology; this enables a far larger portion of the biomass than only the sugars, starches or vegetable oils to be converted into transport fuels. Sugars production



Nozzle deposition probe.

was four to five times as high as with untreated willow; our intention is to increase this amount even further.

In co-operation with Nedalco, we have come up with a design for production of bio-ethanol from wheat straw as well as a project for recycling beet pulp.

The unit is also actively co-operating with other parties; together with WUR-agro technology & food sciences group we have organised the Biorefinery Network, with the goal of bringing developers and users together and drawing up a vision and a road map for the future. Another co-operative effort with TAUW, WUR-AFSG and WUR-PRI is directed towards mapping out the national potential for energy production from water plants.

Jan Willem Erisman: "We have already received international recognition for our work in this new field of research, resulting in an assignment from

the European Commission for the large Integrated Project BioSynergy in the field of biorefinery and biofuels. Our international position has also been strengthened by our participation in the EU Technical Platform on Biofuels, where we must formulate a strategic research agenda for the seventh R&D Framework Programme."

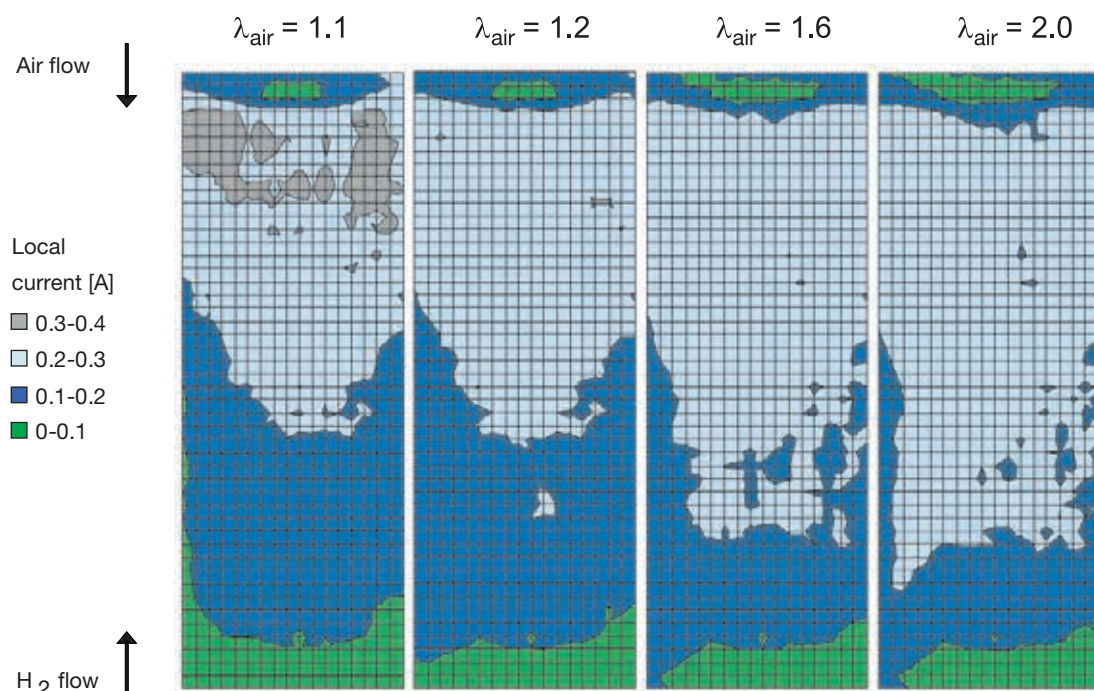
Jan Willem Erisman



Jan Willem Erisman



“ECN’s work on hydrogen is developing in the direction of practical applications”, according to Hydrogen and Clean Fossil Fuels (H2SF) unit manager Frank de Bruijn. “We organised a well-attended and successful hydrogen workshop for managers and policy makers, addressing practical issues such as safety, permits, setting norms and market developments.” Frank de Bruijn: “The orientation of hydrogen developments towards practical issues is also visible in the work of the Dutch Hydrogen working group, formed in 2006 as part of the New Gas Transition Platform, in which many parties involved in hydrogen in the Netherlands are represented. In its report ‘Waterstof, brandstof voor transitie’ (Hydrogen, fuel for transitions), the working group sketched the transition routes to hydrogen for the Netherlands, and indicated three areas where hydrogen applications might show the highest potential. The introduction of hydrogen as an energy carrier would be given a terrific impulse if these areas were to be addressed quickly.”



Measurement of the local electricity production under various air supply levels λ_{air} (864 spots, 400 cm² cell, average stream density of 400mA/cm²).

The Hydrogen research programme of ECN is directed towards developing technology for low-temperature and high-temperature fuel cells (PEMFC and SOFC), and the necessary production of hydrogen. Utilisation in the transport sector and decentralised electricity generation are the leading priorities. Three Dutch consortia have been co-operating in these priorities since 2006. On top of all this, EU projects are very important for ECN.

Reforming

The research that ECN performs on the subject of reforming hydrocarbons is directed towards producing hydrogen for the PEMFC and the SOFC from liquid fuels, especially diesel. Due to the low operating temperature of the PEMFC, the quality of the hydrogen must be very high. The SOFC, which is generally being operated at temperatures of between 750 and 950°C, can be fed by reformat streams (the product of primary reforming) containing large concentrations of methane and carbon monoxide.

ECN was able to couple a diesel reformer to a SOFC cell for the first time last year. Short-term experiments indicated that CPO (catalytic partial oxidation) reformat can be used as feed for an SOFC.

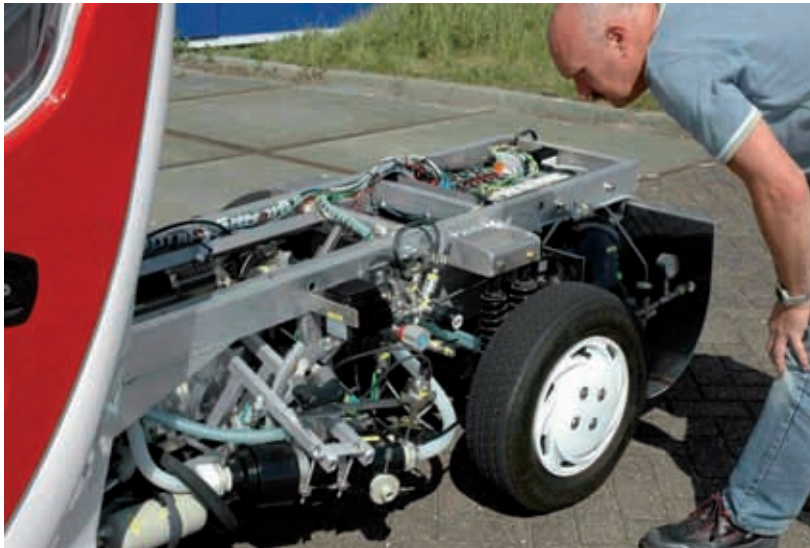
Gas purification during reforming diesel for the PEMFC is a very complex process. The presence of higher hydrocarbons quickly leads to deactivation of the gas purification catalytic converters. Still, in the context of the European BIOFEAT project, we have been able to produce a hydrogen-rich reformat with less than 10 ppm carbon monoxide with a bio diesel conversion equivalent of 10 kWe. The quality and efficiency of the reformat satisfied the requirements set, and the project was completed successfully.

PEMFC

The research ECN conducts regarding the PEMFC is aimed at developing cell and stack technology and demonstrating it at the system level. Mobile applications are the priority, but stationary applications will also profit from the technology developments.

The current generation of PEM fuel cells works at low temperatures (approximately 80°C), requiring very pure hydrogen. If the temperature could be raised to 120 - 130°C, the total system costs could be considerably decreased. Much of the material engineering work on the PEMFC in the unit is

HydroGEM vehicle with fuel cell, without cargo floor.



devoted to this task. At the moment we are looking for new proton conducting polymers and other materials suitable for these higher temperatures. Other projects involve testing materials for electrodes and separator plates with the goal of increasing their performance and their durability.

One of the highlights in the development of the PEMFC in 2006 was the completion of the HydroGEM, a utility vehicle powered by fuel cells. The vehicle has been in use since July 2006 and has been displayed at many events including the Grand Assembly on Hydrogen and Fuel Cells in Brussels, where the HydroGEM participated in a 'fuel cell vehicles ride and drive'. In October, the hydrogen filling station at ECN was officially opened by State Secretary Van Geel.

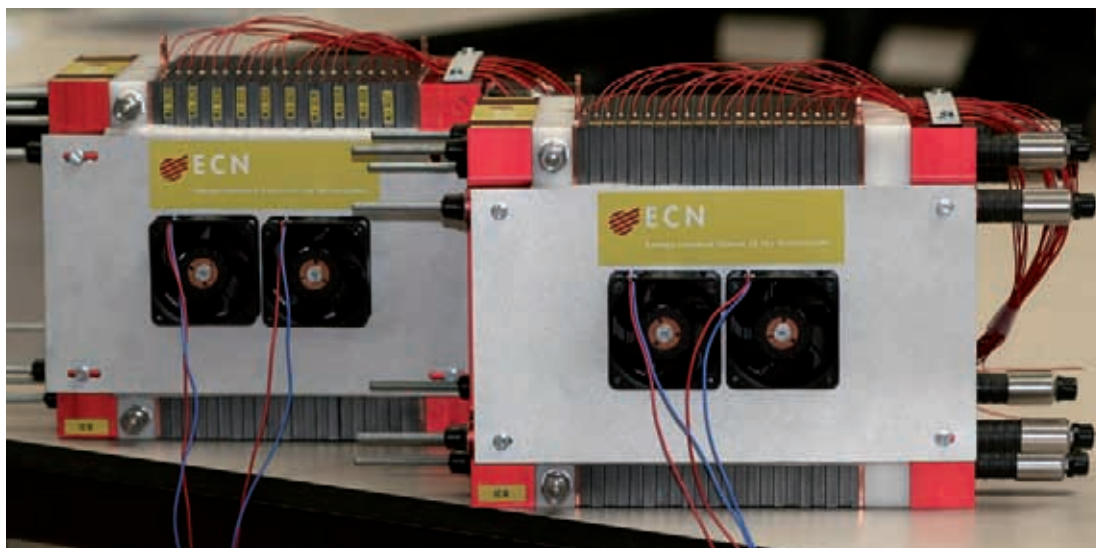
In the EU project Revcell, ECN and its partners developed a reversible fuel cell that not only produces electricity from hydrogen, but can also produce hydrogen from electricity. One possible niche market for this technology is the aerospace industry. ESA has financed a Norwegian company to purchase such a reversible stack with twenty cells, build by

ECN, enabling them to evaluate this technology for its use in space.

SOFC

The unit develops cell and stack technology primarily, but not exclusively, suitable for stationary systems running on natural gas in order to improve their durability, robustness and to lower their cost. We have worked for and co-operated with H.C. Starck for further developments in the cells. The work for H.C. Starck has resulted in a number of significant improvements in the areas of performance, mechanical strength, sulphur tolerance and oxidation reduction cycles. This makes the SOFC less vulnerable to alternating exposure to fuel and air.

One development oriented more towards the long term is the operation of the SOFC at temperatures of 600°C. In this context, a cathode has been developed with a low electrical resistance and a high catalytic effect at that temperature. We have also made significant progress in the field of stack development, having met all of the year's goals for performance and durability.



The reversible stacks supplied in the context of the EU REVCELL project.

Hydrogen Transitions and Infrastructures

The unit also conducted studies on different transition strategies and infrastructure. This was partly to provide direction to our own research programme, and partly to contribute to the national and international discussion on hydrogen.

In the EU framework programme, Hyways is an influential hydrogen project, in which amongst other issues the CO₂ emissions for various hydrogen chains ('well to wheels') are analysed for various countries. This has led to some surprising conclusions. Fuel cell hybrid vehicles running on hydrogen made from natural gas results in 25 to 40 percent less greenhouse gas emissions than hybrid cars with an internal combustion engine. One exception to this case is if the hydrogen is transported to fuel stations in liquid form. If this is the case, then CO₂ capture and storage will be necessary to reach the stated goals.

In the EU project Naturalhy we have analysed the effect of mixing hydrogen with natural gas, to be followed by the separation of pure hydrogen at the end user. As only a part of the hydrogen can then

be separated from the mixture, this requires more energy than other methods of hydrogen transport. This and other practical reasons make this technique unattractive.

Frank de Bruijn

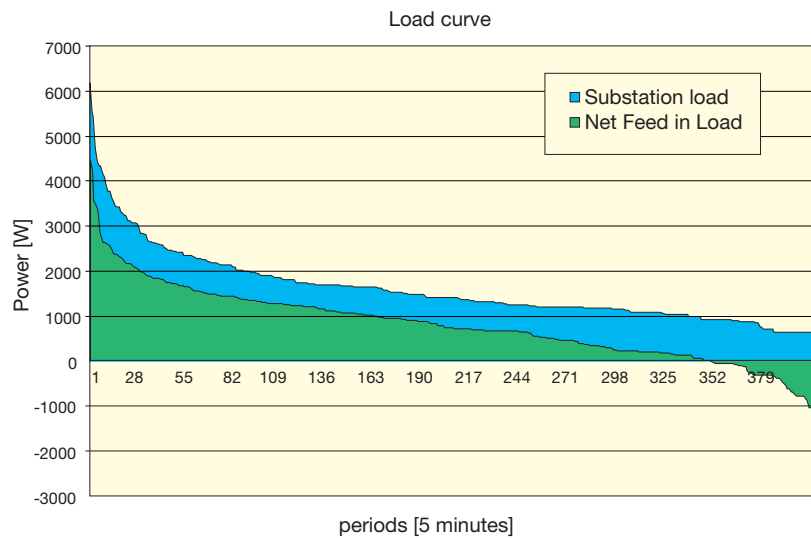


Frank de Bruijn

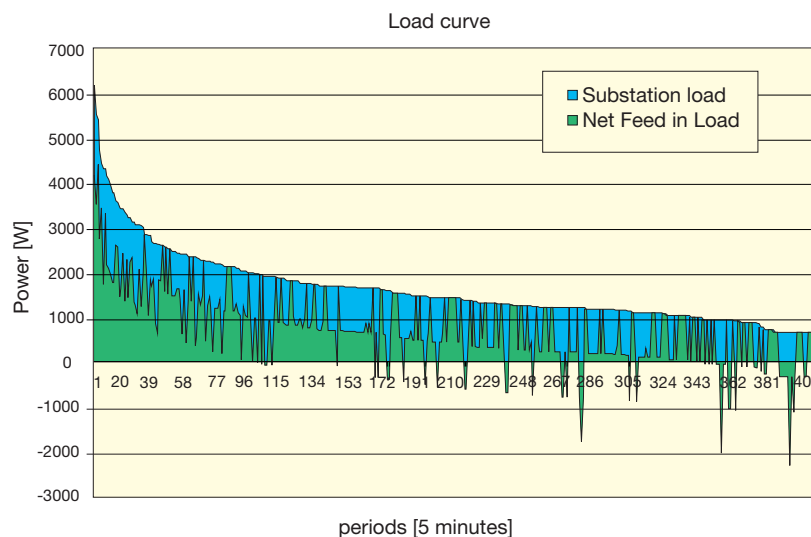
Research Intelligent Energy Grids



As the energy transition takes more concrete form, the ‘Intelligent energy grids’ study field will increase in importance. This is primarily a consequence of the growing share of non-controllable sources of electricity, such as solar and wind energy, and from micro-heat installations. This will increase the importance and value of regulating mechanisms for levelling changes in supply and demand in the electricity net. This is the first priority of the Intelligent Energy Grids section of the EGON (Energy in the built environment & Intelligent energy grids) unit. One subject gaining close attention is net coupling and net quality when many different sources of electricity are coupled to the net. The long-term programme Intelligent Energy Grids is still new. Marije Lafleur, EGON unit manager: “2006 was the year of setting up the long-term project, which became definite at the end of the year. We are continuing activities that had already begun, but for which we had not yet built a formal structure. With the energy advisory commission’s approval, the programme can now really begin.”



Load duration curves for an LV micro-heat power coupling cluster. Co-ordination with agent algorithms lead to a lower peak load; however, inspection of the lower graph indicates that better management for simultaneous peaks and micro-heat power coupling generation is necessary by modelling the substation as a learning agent. This is one of the goals stated in the Operational Plan on Intelligent Energy Grids for 2007.



Load duration curves for an LV micro-heat power coupling cluster.

But the unit can still score even in new areas of work: “The unit was successful in acquiring new projects, especially practical experiments in the field of supply-side/demand-side management. These projects make it possible to couple considerably more decentralised capacity to the electricity network. Our practical experiments show that it will not be long before these systems can be installed in real-world conditions”, says Lafleur.

ECN also developed the PowerMatcher, an algorithm with which supply and demand can be tuned to one another based on supply curves, generated by software agents in the local micro-markets. The PowerMatcher has been applied to the real-time

management of the disbalance in the portfolio of a party responsible to the programme (an organisation that has contracts to supply electricity for TenneT). This has enabled PowerMatcher to prove itself in simulations and in practical applications, and we have gathered a significant amount of data to refine the programme further. This field test took place in the context of the CRISP project, which is now complete and will soon be followed by the EU supported project INTEGRAL.

In a practical experiment with Gasunie, the PowerMatcher was used to co-ordinate five micro-heat power installations in an electricity network connected via an ICT network, in such a way that simultaneous peak load could be prevented in a



part of the net. The results of this experiment are illustrated in the first set of graphics. The top graph indicates the individual sub-station's load duration and that of the micro-heat power coupling, decoupled from time. The graph below illustrates the time-coupled data.

In one of the test houses on the ECN grounds, we have developed and tested an algorithm applied to real-time supply, return supply and storage of electricity and heat in order to optimise all of these activities behind the meter during the course of the year.

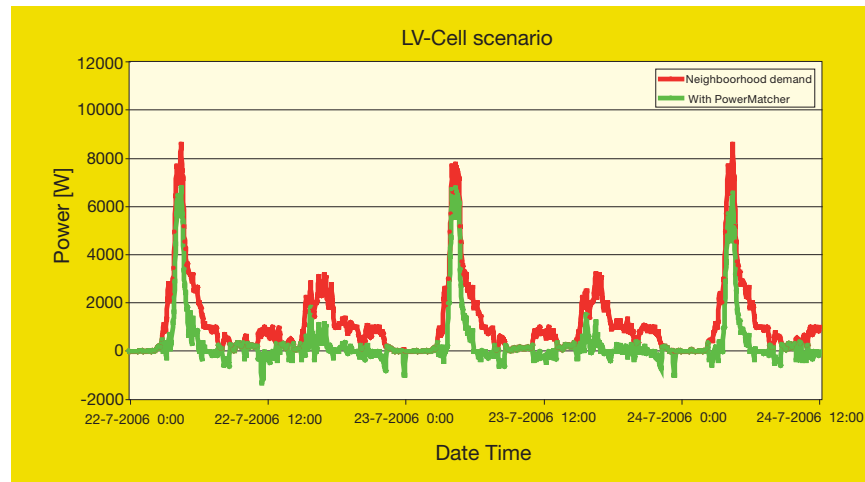
We have also performed related research in electricity storage. The work in 2006 consisted mainly of characterising lithium-ion batteries for the conditions expected during net-coupled storage. In addition, we have drawn up a model for characterising a complete storage system, as existing models do not seem to satisfy the requirements as they are limited solely to the use of batteries.

The international interest in demand-side management of electricity is growing, and Dutch net administrators have also expressed interest in this

subject. In the context of the IEA, we therefore organised a mini-symposium in Amsterdam. Our inventarisation of the opportunities and possibilities was warmly received by our (potential) clients. Together with KEMA, we have gone on to study a number of cases in more depth.

The unit's priorities are net coupling and the quality of electricity generated by decentralised sources, as well as their consequences. Supply from wind farms or heat-power installation can cause instability in the net and effect the quality of the electricity (Ampères). Powerful computer models should provide more insight into the threats resulting from an increase in decentralised power generation, as well as the possible solutions, such as regulation based on co-ordination algorithms. We spent a considerable effort in building such models in 2006, as well as validation of existing installations. Part of this work involved modelling various types of wind farms.

Another part dealt with very small-scale electricity generation with micro heat-power installations. Together with TU/e, we have created a simulation



The effect of 5 micro-heat power systems on the pattern of local electricity demand: preliminary results.

model of an existing test net using such installations in Lelystad, using a scientific calculation package called Matlab-Simulink. In one of the first tests in 2006 with a similar net model, we found that the main net must primarily supply reactive power when many decentralised sources are connected to the low- and intermediate tension net. This causes unnecessary transport losses and is therefore undesirable for the net administrator. Supply and demand solutions for local generation of reactive power similar to the PowerMatcher seem to be suitable tools for solving this problem. Solutions will have to be tested in the laboratory before being put into practice.

Marije Lafleur



Marije Lafleur

Clean Fossil Fuels



The Clean Fossil Fuels section of the Hydrogen and Clean Fossil Fuels unit (H2SF) is focused primarily on CO₂-capture and storage. “In the Netherlands, all of the parties involved in this field have bundled together in the context of the Transition Platform New Gas. The platform primarily studies which conditions are necessary for CO₂ capture and storage to occur”, says unit manager Frank de Bruijn.

Presentation of the Option Document Emissions 2010/2020. This study explored which options the Netherlands has in order to reduce greenhouse gases before 2020. At a mutual press conference organised on Tuesday, 14 February 2006 by ECN and the Netherlands Environmental Assessment Agency (MNP) the study was presented to State Secretary Van Geel.

Research at ECN is focussed on reducing energy losses and lowering costs of CO₂ capture. The focus is placed on the development of process-integrated capture technologies for CO₂ and on the complete conversion of the fuel. This often results in concentrated CO₂ streams and therefore in an energy-efficient capture process.

The basis for our current R&D programme on CO₂ capture technology development was laid via the national CATO project (CO₂ capture, transport and storage). In CATO, ECN is developing Pd/alloy membrane- and sorption enhanced reforming reactors for CO₂ capture in natural gas combined cycle power plants. In 2007, ECN will build and test a



New test installation for CO₂ capture.

'small' membrane reactor as part of CATO. The test results obtained will be used for further upscaling in the European project CACHET.

The CACHET project, aimed at developing inexpensive CO₂ separation technologies for power plants, started last April. ECN co-ordinates the work package for membrane reactors for CO₂ capture. The membranes tested so far satisfy the preliminary requirements for gas separation, and tests with gases that better simulate real-world situations are planned for the course of 2007. CACHET's objective is to reduce CO₂ capture cost to a level of 20 to 30 €/ton CO₂. It will be a challenge to produce membranes with the necessary performance, but it is not impossible.

ECN has also plays also an important role in another work packages of CACHET 'Sorption-enhanced Water Gas Shift', led by Air Products. The first of two test installations was opened at the end of 2006, and is currently used to test hydrotalcite CO₂ sorbents. A pilot installation which can produce continuous streams of hydrogen and CO₂ was then designed based on preliminary results of these tests. System studies carried out at the same

time showed that power plants equipped with this technology can achieve higher efficiencies than those with the current CO₂ capture technology.

Experiments and thermodynamic analyses have shown that other sorbents than hydrotalcite are necessary in the processes of steam-methane reforming (sorption-enhanced reforming) and auto-thermal reforming (ATR). Both projects therefore looked for new sorbents in 2006.

The GCEP project, a project at Stanford University sponsored by Exxon, Schlumberger, GE and Toyota, with ECN, Delft University of Technology and ETH as the sole European partners, showed that hydrotalcite is neither a suitable material for dense membranes, due to a lack of thermal and therefore mechanical stability. The fundamental properties of hydrotalcite are currently being published in a number of scientific journals, and new studies will soon research whether hydrotalcite can be used in porous membranes. All projects are now looking for promising alternatives.

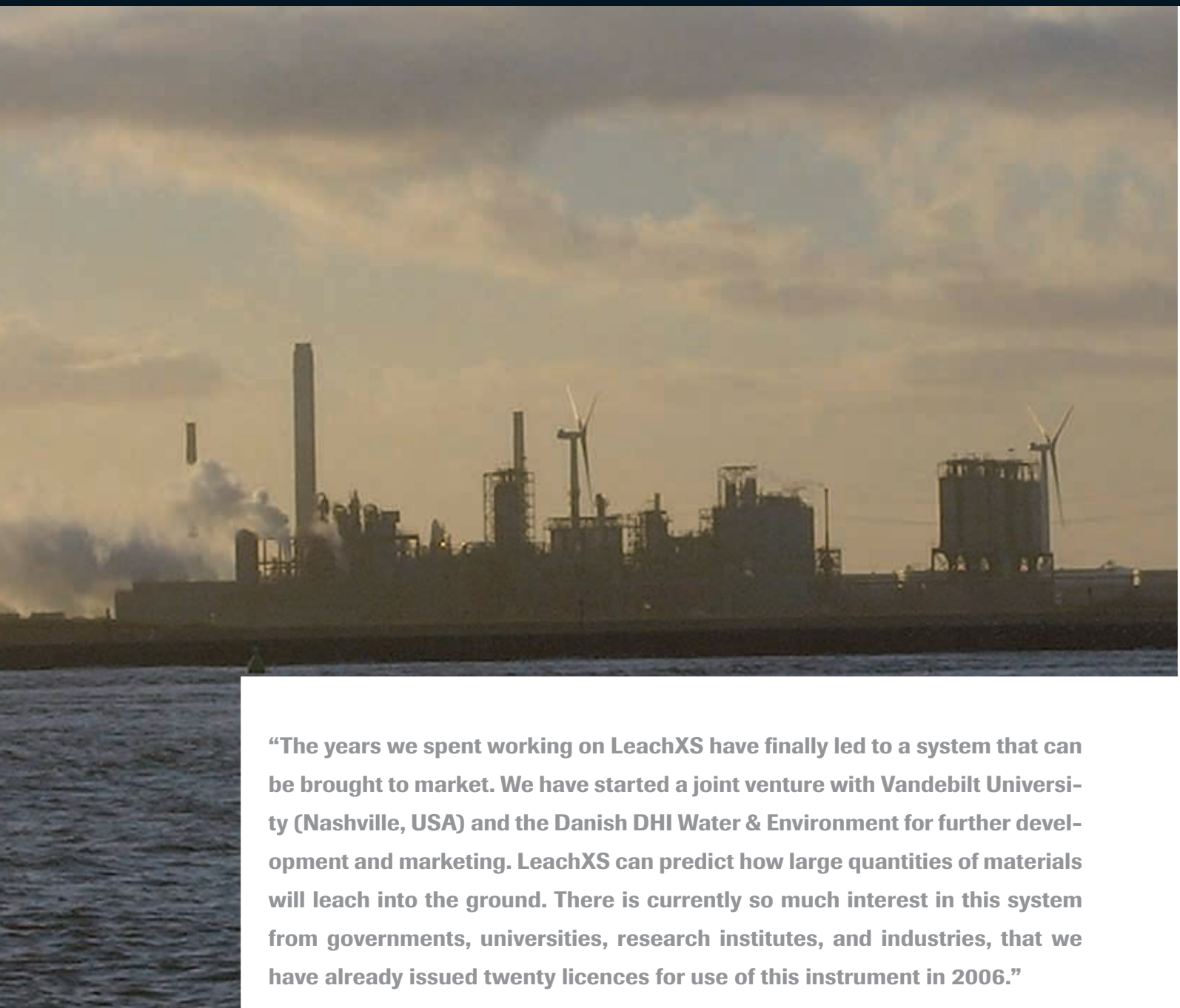
Until 2006, ECN's CO₂ capture programme was primarily directed towards natural gas as a fuel. In 2006 we began a number of activities related to coal-fired power plants. The new CAPTECH (CAPture Technology) EOS-LT consortium is currently studying applications of membranes and CO₂ sorbents in the water-gas-shift-section of a coal gasifier with a steam and gas turbine (IGCC). Within CAPTECH, we are also working on another process for oxygen production for applications in nitrogen-free coal combustion (oxy-fuel).

The unit's clients in 2006 included NUON, which commissioned a short study of possibilities and limitations for CO₂ separation in the Magnum station. Magnum is a IGCC power plant with an electrical output of 1200 MW, which will begin service in 2010. ECN provided an overview of possible technologies for CO₂ capture, and assessed a number of designs for the CO₂ capture section.

Frank de Bruijn



Frank de Bruijn



“The years we spent working on LeachXS have finally led to a system that can be brought to market. We have started a joint venture with Vanderbilt University (Nashville, USA) and the Danish DHI Water & Environment for further development and marketing. LeachXS can predict how large quantities of materials will leach into the ground. There is currently so much interest in this system from governments, universities, research institutes, and industries, that we have already issued twenty licences for use of this instrument in 2006.”

Jan Willem Erisman is very pleased with the success of his unit's product. “Due to our possession of the knowledge on which LeachXS is based, we have been able to contribute to policy development. Our knowledge has been used in drawing up regulations regarding disposal of building materials in the new Besluit Bodemkwaliteit (Soil Quality Decree) that went into effect at the beginning of 2007. This is the first time that a model based on the fundamental speciation (chemical forms) of materials has been used for this purpose. ECN has been working on this model for years. In the past, norms for disposal of heavy metals, for example,



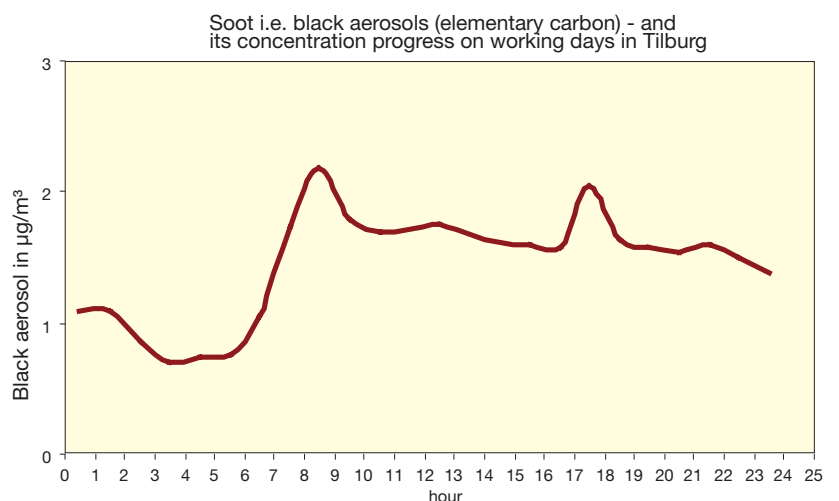
The Sustainable Disposal reports are presented to State Secretary Van Geel.

Foto: Frank Grosveldt, Afvalzorg

only related to the amount of metal in the material, ignoring the (im)mobility of the metal in its chemical form. This Soil Quality Decree forms an important bridge between determining norms and fundamental knowledge about the movement of pollution in the environment.”

In 2006, we completed the Duurzaam Storten project (Sustainable Disposal) after five years of hard work. The project's goal was to minimise environmental pollution; a sustainable disposal dump is inert after only one generation and requires no further maintenance. The final report of this project was presented to State Secretary Van Geel. A follow-up project will study how existing disposal dumps can be made more sustainable.

Also in 2006, the commotion around fine particles settled a bit, but a large number of projects are still being conducted in this field. ECN has developed a soot monitor, with which the amount of soot in the air can be continuously and more accurately determined than by using filters. The research on measuring air quality using MARGAs currently being conducted in the United States seems to be successful and will continue. The MARGA instrument is also utilised in monitoring air quality in advanced cleanrooms in Taiwan. Another project, in conjunction with TNO, involves measuring the concentrations of NO_x and fine particles in the plumes of boats and ships. In August we began a measurement campaign to determine the influence of a strip of vegetation on air quality along a motorway. The



Concentration progress of elementary carbon along the A10 in the course of the day.

concentration of NO_x does seem to decrease due to the vegetation, but the levels of fine particulate matter only seem to decrease in the area directly behind the vegetation.

Air quality was also the subject of a number of model studies. Using a special model, the unit calculated what the influence of traffic and emissions regulations will have on the concentrations of NO_x and fine particles around motorways.

In addition, the unit has set up measurement campaigns for the greenhouse gas methane and for hydrogen. It is important to determine the concentration of hydrogen in the atmosphere before the development of a hydrogen economy, because an increase in the hydrogen concentration will probably have an influence on the lifetime of methane and therewith its climate impact. Finally, we have developed an ammonia analyser for NUON. Ammonia is used behind a DeNO_x catalytic converter in order to neutralise the last traces of nitrogen, and

with the help of the analyser, the ammonia can be more accurately dosed, resulting in less wastage.

Jan Willem Erisman is very pleased about the strong position ECN has been able to take in the area of nitrogen problems in Europe and abroad. "We are leading an EU COST Action oriented towards policy support and a European Science Foundation network programme for co-ordination of the entire European scientific work on nitrogen. We also participate in leading NitroEurope, an EU research programme with 65 partners that is studying the relation between nitrogen and greenhouse gas emissions."

He is therefore satisfied in the developments over the past year: "In 2007, the Environment programme that we wrote for the Ministry VROM will expire. The programme has resulted in achieving almost all of the stated goals. The Ministry has been very content with our quality and method of working: demand-side management, which is a new

Measurement locations along the A50 motorway.





Toad migration on ECN premises.

approach for them. ECN has become an example that the Ministry talks about with other institutes in the field of research management. In 2006 the Ministry VROM decided to finance a continuation of the Environment programme for the period 2008 to 2011, a good result of our efforts. A programme study will be conducted at the beginning of 2007 to determine the content of the new programme."

Jan Willem Erisman



Jan Willem Erisman



Annual average concentration of NO₂ on the ringway around Utrecht in hundredths of a microgram/m³ for the reference scenario in the year 2020. Red indicates levels in excess of the norm.



In 2006 a further expansion took place of the working areas of Engineering and Services (former name Technological Services & Consultancy). The unit is traditionally the technological support unit for research and development in the other units. On 1. January 2006 basis design and modeling of installations were added to the tasks of the unit. More effort is done on improvement and development of production. The department characterising materials was expanded with chemical analysis. “In 2006 the unit has developed itself further to a high standard Dutch knowledge centre for technology”, says Jaco Saurwalt manager of the unit E&S.

E&S started in 2006, together with the researchers of the unit H2SF, with the development of a cheap standard 5 kW polymer fuel cell system. Target is to strongly reduce the costs by using a new approach and new technologies. In connection with the new approach a STW project ‘Integrated technology design of a 5 kW PEM Fuel Cell platform’ was submitted together with the University Twente to develop a new design methodology.



E&S has made an important contribution to the development of the HydroGEM. This vehicle is based on the PEM fuel cell.

E&S represented ECN in the NEN, EIA and CEN committees for the development of standards for analyses and safety with the use of H₂.

Another project of E&S contains the specification of the share of biomass in fuels. The amount of C14 is analysed, a method which is successfully used for years to determine the age of objects containing carbon of organic origin. On the basis of the report of ECN CERN will develop a standard for this method.

An expanding activity is laser treatment. Especially for the projects of the unit Solar Energy, 7 new laser systems with various wavelengths and pulse times are used for instance to improve the isolation of the border of photovoltaic cells.

A lot of work has been done on the characterisation of materials. A new apparatus for thermographic metric measurements was installed. The unit also got a new specialised employee for the measurements.

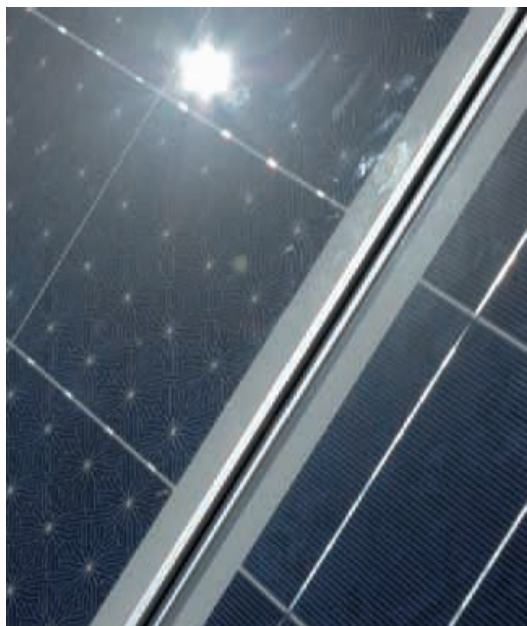
In 2006 E&S gave training in ceramics and material choices. Also the subjects upsizing and downsizing of experiments were handled. In assignment of the Netherlands Institute for Material Research (NIMR) an overview was made of possibilities of coating technologies (publication "New Coating technologies for the middle sized industry"). The tables with the possibilities of the different coatings in several conditions can also be found on the internet.

In 2006 E&S also maintained a broad network with universities, research institutes and specialised companies. Because the knowledge in the unit covers a broad spectrum the unit can manage in house the whole research chain from concept to the fabrication of an installation. E&S also works for parties outside ECN. About 1/3 of the turnover is coming from other parties. In 2006 the unit has developed itself further to a high standard Dutch knowledge centre for technology

Jaco Saurwalt



Jaco Saurwalt



Facility Services



“In 2006 Facility Services have achieved several set support targets. This is our job within ECN, and to do so is in the overall interest of the company.” according to Koos den Hartogh, manager Facility Services.



Catch-up with maintenance



In 2006 a plan has been drafted and approved to catch up with overdue scheduled maintenance. Maintenance activities started in 2006 and we expect to finish according to plan at the end of 2009.

Also attention was drawn to improving the range of products within our cafeteria and to uphold the high quality of our IT infrastructure. Both service targets for 2006 have been completed to our full satisfaction.

Koos den Hartogh



Koos den Hartogh

Quality, Safety & Environment



Begin of demolition of nuclear facilities within ECN. In 2006, ECN completed the demolition of five so-called 'waste wells', used for temporary storage of radioactive waste water. These wells, large underground concrete basins with two tanks and plumbing, have been cleaned and released. The concrete basins were then sawed in two and taken away for recycling. The next few years will see the demolition of the buildings; all nuclear activities within ECN should be finished by the end of 2007.

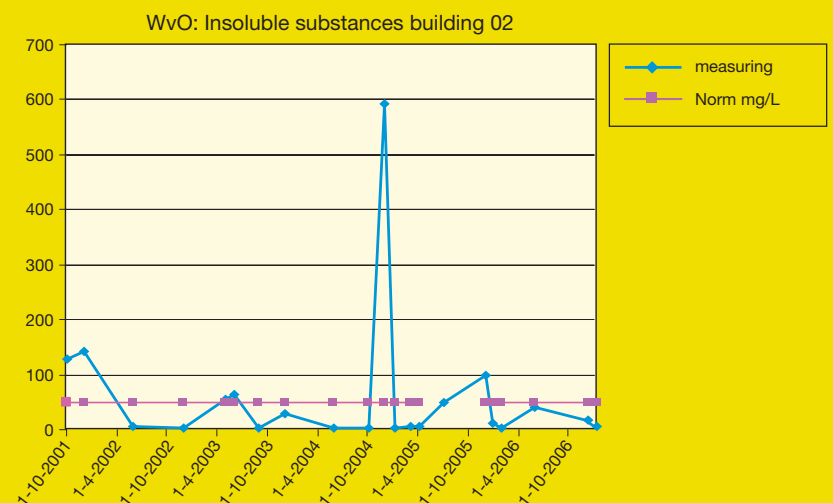
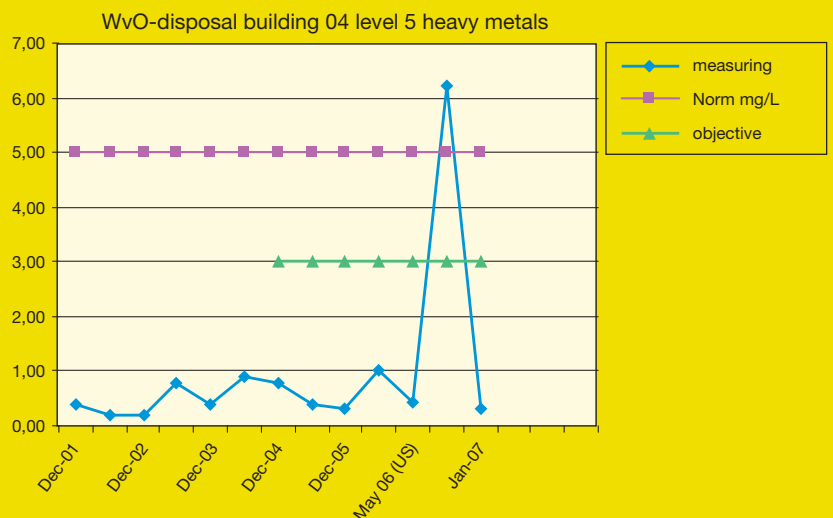




Inspection of waste water disposal by ECN

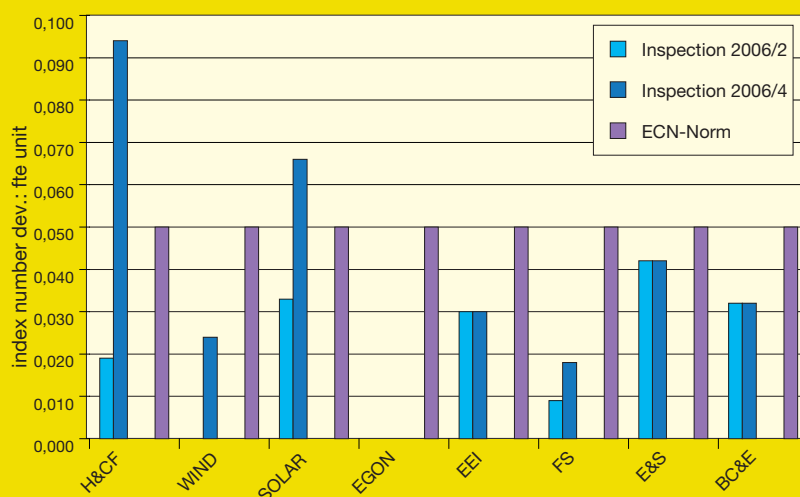
In order to maintain its permit, ECN inspects its waste water disposal at a number of points for heavy metals deposits, organic chemical levels, mercury and insoluble substances. In doing so, we sometimes discover discrepancies. Below are two examples of such discrepancies discovered during inspections:

- At laboratory building 04, the level of heavy metals was slightly higher (6.2 mg/L compared to the norm of 5 mg/L) in the middle of 2006. Despite intensive investigation, the cause of the increase, caused by copper, could not be determined. Repeated measurements indicated that the levels had returned to the normal level.
- At building 02 (disposal of water from a watertight floor) after a number of measurements we replaced the sample drain sensor, as it was probably responsible for the higher sample reading.





Inspection hazardous materials 2006



Inspection of storage of hazardous materials

– Appeals court decision

In 2003, the anti-pollution squad held inspections of all the companies in the Research and industry area in Petten. In February 2007, the Court of Appeals in Amsterdam ruled that ECN must pay a € 20,000 euros fine, with another € 30,000 on probation. The original fine demanded by the public prosecutor amounted to a total of € 500,000. The court took the fact that no environmental damage had occurred into consideration in determining the amount of the fine.

ECN has learned a great deal from this trial. We have held internal inspections by safety specialists (the results of these inspections are illustrated in the graph). Each work space with hazardous materials was checked for 33 different points. ECN strives to maintain a standard in each unit of one deviation per twenty employees (index number value of 0.05). The goal is for each unit to attain this very strict norm.

Risk assessments , OHSAS 18001 and NTA 8620 (BRZO)

In 2006, we performed a number of risk assessments to supplement the general assessment from 2001. This involved machines, physical stress and noise. Based on these assessments, we have taken concrete measures such as replacing or improving machines and work

spaces. At the end of 2006, ECN decided to apply for OHSAS 18001 certification. This is a norm for a management system for working conditions. Together with the comparable norm ISO 14001 (environmental management), which ECN already possesses, these two norms

form the pillars under NTA 8620. ECN is a subject to this Netherlands Technical Agreement, created in 2006, which fulfills the requirements of the Major Accidents (Risks) Decree of 1999 (BRZO), also known as the Seveso guideline.

Adopting a modified version of the Dow-index (BRZO).

The well-known Dow index has been used for decades to identify risks in process installations. In the context of the BRZO ECN adopted a modified version of this index adapted to the scale of pilot-test installations in 2006. Based on the risk level determined, we performed safety and environmental studies and utilised a method for management of change. In addition, we have appointed separate tasks including the necessary authority in order to

responsibly work with the installations. An in-company training course 'Safety & Environment in the process industry' began in September 2006 and will end in the summer of 2007.

Jos Schrover



Jos Schrover





As an employer, ECN has an international appeal. In 2006 more focus was set on the recruitment of young professionals. Also on an international level, ECN has been able to attract the attention of potential employees which resulted into more enrolments. The number of foreign-born employees is growing, as is the number of their nationalities. “Due to rising assignments and decreasing personnel numbers, job openings are increasing. We have put a lot of energy in 2006 into bringing ECN as an employer to the public’s attention.” says Marlout Corba, interim head of the department Personnel & Organisation.

Vacancies			
	Number	Fulfilled	Vacant
2005	82	67	15
2006	136	98	38

Employees

In December 2006 ECN employed 607 people, of which 480 men and 127 women. The average age of the male employees was 44 years, with an average of 13 years employment. The average age of the female employees was 39 years, with an average of 10 years employment.

% Contract of employment			
	Male	Female	Total
... - 19%	5	13	18
20% - 39%	5	6	11
40% - 59%	8	10	18
60% - 79%	18	10	28
80% - 99%	77	40	117
100%	367	48	415

New ECN employees in 2006	
Original Branch	Number
Trade	2
ICT	3
Industry	7
Education	12
Research institute	10
Training	7
Government	2
Other	11
Unknown	3
Total	57

Employees leaving ECN in 2006		
Reason for leaving	To branch	Number
Own request	Industry	7
	Education	2
	Research institute	8
	Other	4
	Unknown	2
Pension		15
End of temporary employment contract		5
At request of ECN		3
Deceased		1
Total		47

Retirement pensions

2006 was notable for the attention given to the pension problem. Joint efforts by the management and the Works Council provided a good solution, becoming effective as from January 1st, 2006.

People Management

In the course of 2006, ECN made a clear choice to apply 'people management'. This means that the company encourages its personnel to develop their talents and qualities. This in turn benefits the company, as the employee is the key to achieving success.

So as to implement People management, management and staff are in need of policy and management instruments. The first priority is to develop the competences of the employees, to lay a firm foundation to the new functioning system and to set up transparent evaluation procedures.

People management is given concrete form in three projects:

- Determining competencies that are required for those functions with emphasis on the individual person and the demands placed on them.
- Adopting new function descriptions.
- A new function evaluation cycle.

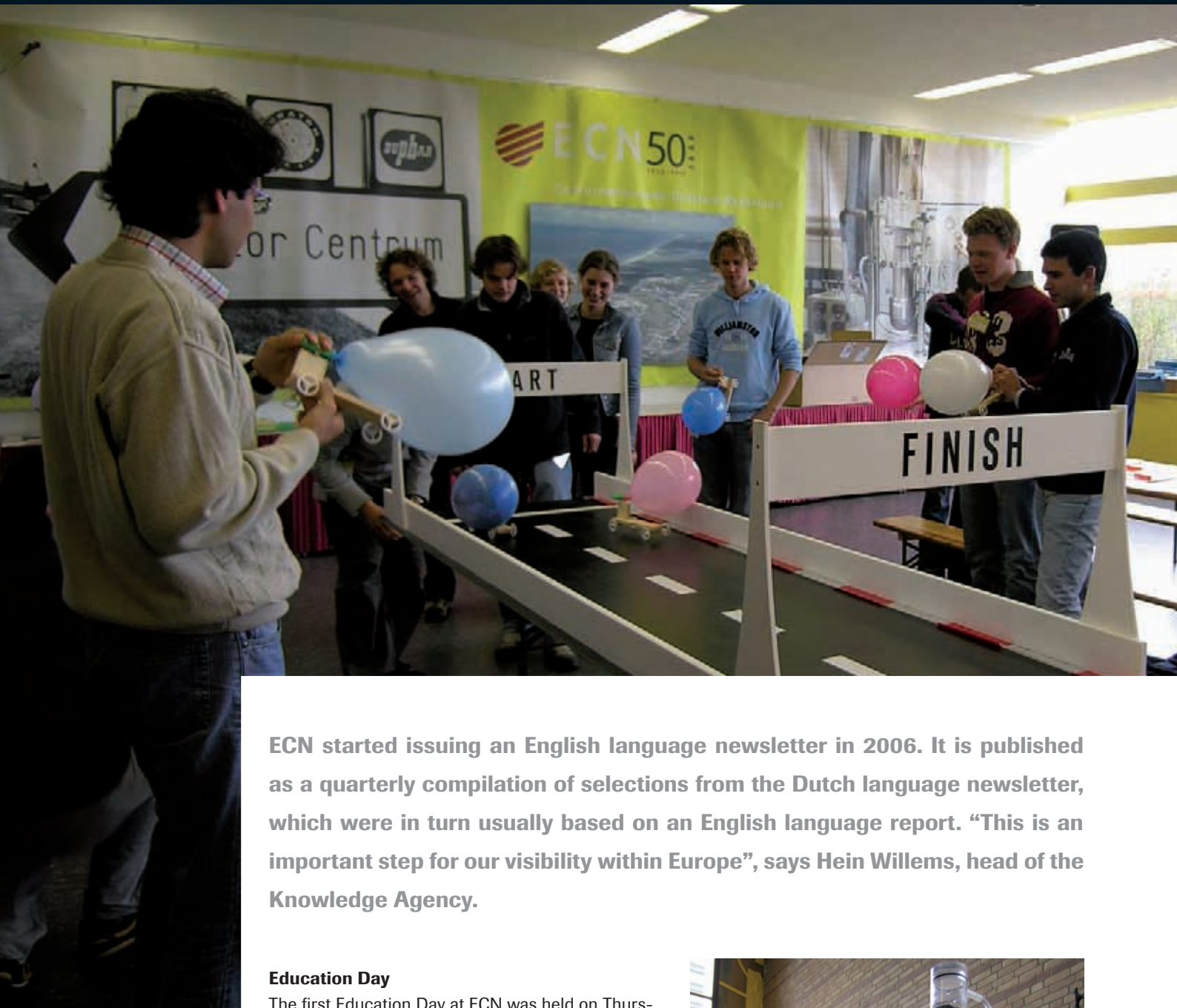
Many individuals were involved in these projects, and there is a broad base of support for these innovations. The firm Leeuwendaal provided guidance during this transition. The official kick-off occurred in the fourth quarter of 2006, and further execution of the people management projects will continue to receive priority in 2007.

Marlout Corba



Marlout Corba

ECN in the Public Eye



ECN started issuing an English language newsletter in 2006. It is published as a quarterly compilation of selections from the Dutch language newsletter, which were in turn usually based on an English language report. “This is an important step for our visibility within Europe”, says Hein Willems, head of the Knowledge Agency.

Education Day

The first Education Day at ECN was held on Thursday, 20 April at our grounds in Petten. The day was intended for university and other higher education students interested in energy-related questions. It was an ideal opportunity for students to take a look backstage at ECN.



Primary school project

More than 6,000 primary school students from the northern part of the province of Noord-Holland have visited ECN over the past two years. On Thursday, 6 July 2006, the 150th school class visited; group 8 from the Aloysiusschool in Schagen. These students made solar cells and performed exciting experiments in gasification of chicken manure! Noord-Holland Provincial Executive Moens, who is responsible for the energy portfolio, also attended. Another special group of students was from the Montessori primary school in Heerhugowaard, who visited ECN together with students from England, Germany and France on 1 June as part of the European Comenius project.

Publications 2006	PS	EGON	EEI	BC&E	H&CF	WIND	Solar	E&S	Total	Plan
ECN reports (excl. RX serie)	37	14	24	34	15	50	16	11	201	239
Peer reviewed articles in scientific journals	14	6	8	17	10	3	6	0	64	60
Peer reviewed articles in magazines	6	17	10	2	0	0	0	0	35	30
Conference papers	48	14	10	60	25	6	46	4	213	163
Books and chapter of books	12	3	1	3	0	0	0	0	19	28



JetNet

In the fourth quarter, ECN also participated in the JetNet Career Day in the Evoluon in Eindhoven. More than 160 secondary school students assembled solar cells from the ManSolar packet. JetNet stands for Jongeren en Technologie Netwerk Nederland (Youth and Technology Network Netherlands). In this project, government, industry and secondary education work together to encourage students to begin technical studies.



Hein Willems





Nuclear Research and consultancy Group (NRG) is the top Dutch expertise centre in the field of safe applications of nuclear technology. NRG performs research, product and process development, and consultancy for governments and industry. NRG is also the largest producer of radionuclides for medical, industrial and scientific applications in Europe. NRG's ambition is to contribute to making nuclear technology more sustainable.

A very large commission for NRG was the In-Service Inspection of the nuclear power plant Borssele.

NRG is a partnership formed by the merger of ECN and KEMA's nuclear activities. KEMA transferred its shares in NRG to ECN on 1 December 2006. This was an important step towards making NRG and ECN independent organisations under a common holding. The new structure will preserve the synergy between NRG and ECN, as well as their separate identities.

Increase in commissions

Both the government and the industry in the Netherlands and abroad increasingly approach NRG for their expertise. NRG performs an irreplaceable task in making preparations and realising an expansion of nuclear capacity. One of NRG's large commissions in 2006 involved the In-Service Inspection of the nuclear power plant in Borssele. After the necessary months of preparation, NRG completed the work within the planned time frame, to the satisfaction of the client and the nuclear regulatory authorities.



Energy

The international network that NRG has established over the years is an indication of the quality of service it provides, and has led to another increase in international commissions. In 2006 NRG signed a contract with the French-German combination Areva to build the EPR - European Pressurized Reactor - in Finland. NRG will participate in the safety engineering part of this international project. Initially, some NRG employees will work at Areva in Erlangen (Germany) to become acquainted with the 'work flow' inside the firm and to learn the necessary procedures. In 2008, NRG in Arnhem will function as the 'first point of contact' to recruit more people for the project.

In addition, British Energy Generation Ltd (BE) has selected NRG as a partner for an ageing study. BE wishes to know what will be necessary to keep its nuclear power stations in service and safe for a longer period than originally planned. BE chose NRG due to its expertise in the field of graphite and the possibilities of accelerated aging of graphite samples using a high flux reactor (HFR). British Energy was not looking for 'just' a neutron irradiation source, but a problem solver, and therefore chose NRG.



Artist impression EPR in Finland



Transportation controls at the border of Latvia.

Environment and health

NRG has also been active in the fields of environment and health. The organisation performed research in an international context regarding safe disposal of long-lived radioactive waste. NRG won the contract together with the Swiss Colenco Power Engineering AG and GRS*, to support the GSF** in its preparations for closing the Asse mine. This is an old salt mine near Braunschweig (Germany), in which radioactive waste is stored. NRG has also performed a project in co-operation with the Latvian company SIA Estonian, Latvian & Lithuanian Environment to improve the suppression of illicit trafficking and smuggling of fissionable materials and other radioactive substances from and to Latvia. In the field of health, the last reactor cycle of the HFR achieved a record production of molybdenum-99, the radionuclide most important for medical diagnostics today.

* Gesellschaft für Anlagen- und Reaktorsicherheit

** Forschungszentrum für Umwelt und Gesundheit



The building of the Jaap Goedkoop laboratory.

Nuclear infrastructure

The HFR is the throbbing heart of the nuclear infrastructure in Petten. Last May, NRG started the HFR for the first time with a core of exclusively low-enriched fissionable material. This transformation or conversion of high-enriched (HEU) to low-enriched uranium concluded a long-term process. With this conversion, Petten provided an important contribution to the international efforts to reduce usage of proliferation-sensitive high-enriched uranium. NRG also works on expanding and renovating the nuclear infrastructure by building the Jaap Goedkoop laboratory, a new, modern radiologic lab that is expected to be completed in 2007.

International interest

International interest in using the HFR is increasing significantly, both for research and for production of medical radionuclids and semi-conducting materials. In order to exploit this interest, the European Commission (owner of the HFR), and the Dutch government have decided to organise the financing of scientific applications of the reactor in a European Joint Undertaking. In order to satisfy the demand for irradiation capacity after 2015, NRG is working on Pallas, a new materials test reactor which will replace the HFR after 2015. This new reactor was named Pallas after the Greek goddess Pallas Athena, the martial woman often associated with prosperity and peace, who is also the symbol for beauty, wisdom and craftsmanship. Based on the experiences with the HFR and new technical possibilities, Pallas will have a broad field of applications, although its primary function will be for educative, scientific and technological research, and radionuclide production purposes. The specifications were discussed with a number of reactor suppliers. In the second phase, NRG will begin drawing up detail specifications and applying for permits.



NRG directors: André Versteegh (l) and Rob Stol (r).

Policy studies

- Ir. E.C.R.H. Eijkelberg (Chairman)
Ministry of Economic Affairs
- Drs. H.E.G.D. Dunsbergen, AER
- Ing. F.J. de Groot, VNO-NCW
- Dr. J.T.N. Kimman, SenterNovem
- Drs. J.A. Oude Lohuis, MNP
- Ir. E.J. Postmus, Gas Transport Services B.V.
- Dr. F. Vlieg, Ministry VROM

Wind Energy

- Ir. G.F. Bakema, Essent
- Ing. van de Brug, Ballast Nedam
- Prof.ir. W.L. Kling, TenneT
- Prof.dr.ir. G.A.M. van Kuik, TU Delft
- J.T. Olesen, VESTAS Wind Systems A/S,
Denmark
- Dr. D. Quarton, Garrad Hassen & Partners,
England
- M.Sc. F. Rasmussen, Risø National Laboratory,
Denmark
- Ir. H.P.G.M. den Rooijen, Shell Wind Energy B.V.
- Dipl.Ing. V. Schellings, GE Wind Energy, Germany
- D.P. Molenaar, Siemens Nederland B.V.

Solar Energy

- Prof.dr. Christoph Balliff, University of Neuchatel
- Prof.dr. Paul Blom, University of Groningen
- Dr. Martin Fleuster, Solland Solar Energy BV
- Dr. Oliver Hartley, Q-Cells
- Mr. Frans van den Heuvel, Scheuten Solar
- Dr. Lars Podlowski, Solon AG
- Prof.dr. Ronald van Zolingen, Shell Solar and
University of Eindhoven
- Dr. Frank Witte, observer from SenterNovem

NRG

- Ir. J.C.L. van Cappelle, EPZ
- Dr. H.D.K. Codée, COVRA
- Prof. dr. ir. T.H.J.J. van der Hagen, RID
- Dr. P.J.W.M. Müskens, Ministry VROM
- Ir. G.R. Küpers, Kandt Management (Chairman)
- Mw. mr. A. van Limborgh, Ministry VROM
- Ir. P.G.T. de Jong, Urenco Nederland B.V.
- Ir. G.C. van Uiter, Ministry Economic Affairs
- Prof. dr. ir. A.H.M. Verkooijen, RID

Biomass, Coal & Environmental research

- Ir. M. van Berlo, Afval Energie Bedrijf
- E. Goudappel, Jacobs Nederland B.V.
- Ir. H. Klein Teeselink, HoSt
- R. de Kler, Nuon
- H. Kursten, Eneco
- Ir. G.R. Küpers, KandT Management B.V.
- Ir. K.W. Kwant, SenterNovem
- W. Schonewille, Havenbedrijf Rotterdam N.V.
- E. van Seventer, Agrotechnology & Food
Innovations
- Dr.ir. W. Willeboer, Essent Energie Productie

Built Environment

- De heer W. van den Bogerd, Ihto-Van der Beijl B.V.
- Dr. L. van Bree, RIVM
- Ir. H.M. Croes, RGD Ministry VROM
- Ir. C.J.G. Hamans, Rockwool
- Ing. P. Hameetman, BAM Vastgoed
- De heer F.W.M. van Hunsel, Essent Retail
Services B.V.
- Ing. J.J. Overdiep, Gasunie
- Ir. T.H. Reijenga, BEAR Architects
- De heer R. van der Meer, UNETO-VNI
- De heer J. Verlinden, Ministry VROM
- De heer H. Westra, TU Delft
- Dr. G.J. Zijlstra, Zijlstra Management & Advies
- Prof.dr.ir. R. van Zolingen, Shell Solar Energy
Systems B.V.
- De heer P. Heijnen, SenterNovem

Hydrogen & Clean Fossil Fuels

- E. Lysen, University of Utrecht
- F. Denys, SenterNovem
- I. Williams, Air Products
- J.P.P. Huijsmans, Shell Global Solutions
- J.P. Reintjes, Nefit
- M. Steen, JRC-IE
- R. de Kler, Nuon

Energy Advisory Committee

- Prof.dr. E.M. Meijer, Unilever (Chairman)
- Ing. T.P. Bokhoven, ConSolair B.V.
- Dr.ir. M.J. Groeneveld, Shell International Exploration & Production BV
- Dr.ir. T. van Herwijnen, ETC Energy Technology
- Mw.dr.ir. R. Janssen-van Rosmalen, Energy Plus
- Prof.dr.dipl.ing. M. Kühn, University of Stuttgart
- Mr.dr. P.W. Kwant, Shell International BV
- Ir. G.J.M. Prieckaerts
- Prof.dr. J.H.W. de Wit, TU Delft

Accountability and corporate governance

The Board of Directors and the Supervisory Board endorse the general principles and starting points of the Dutch Corporate Governance Code (Code Tabaksblat), namely integrity and transparency of actions, proper supervision of these actions and accountability for these actions. Although this Code focuses on Dutch companies quoted on the stock exchange, the Board of Directors and the Supervisory Board decided in 2004 to implement the elements from the Dutch Corporate Governance Code that are also relevant to ECN. To this end, regulations were drawn up in 2005 that incorporate the elements taken from the Dutch Corporate Governance Code that are relevant to ECN. These regulations remained unchanged in 2006.

The Board of Directors of ECN consists of one statutory director and one assistant director. The statutory director is the chairman of the Board of Directors. He/she bears final responsibility for the company as a whole and is accountable to the Supervisory Board. The statutory director is appointed, suspended and dismissed by the Supervisory Board. The current statutory director was appointed for an indefinite period. The Supervisory Board decides on the statutory director's remuneration.

The Supervisory Board consists of six members. The task of the Supervisory Board is to supervise the management of the foundation by the Board of Directors and the general performance of the foundation and the companies associated with it. The Supervisory Board advises the Board of Directors. The members of the Supervisory Board are appointed on the recommendation of the Supervisory Board by the Minister of Economic Affairs. The Supervisory Board consults the Board of Directors and the Works Council when drawing up its recommendations. Applicants have to fit the desired profile of the Supervisory Board. When drawing up this profile, the Supervisory Board takes into account the nature of ECN, its activities and the desired expertise, experience and independence of its members. The Supervisory Board evaluates the profile every year. A member of the Supervisory Board is appointed for a period of four years and can be reappointed a maximum of twice.

The Board of Directors and the Supervisory Board are responsible for the corporate governance structure of ECN and are accountable on this point to the Minister of Economic Affairs. The Supervisory Board provides the Minister of Economic Affairs with all the requested information.

Supervisory Board Report

The Supervisory Board met four times in 2006 in regular session, in addition to one special session. The Board of Directors was present at each meeting. One member was absent from one meeting. The following topics, among others, were covered in the meetings:

Financial matters, including the annual report and accounts, the periodic financial reports, the investment plan, the operational plan and participations. The annual report and accounts were dealt with in the absence of the external auditor.

Pension issues. In every meeting the progress made regarding the pension issues was discussed with the Board of Directors. The special session meeting was also devoted to pension issues.

The Strategy Plan 2007-2011. ECN's strategy plan was discussed and determined in two meetings.

Other topics. The R&D plan, the report of ECN's (internal) scientific advisory council, and the structure of ECN and NRG. A member of the Supervisory Board was present at three of the six consultation meetings of the Works Council with the Board of Directors.

The Supervisory Board has two committees, the Audit Committee and the Remuneration and Appointments Committee, both of which prepare special topics for the Supervisory Board. As part of the Corporate Governance, regulations were drawn up in 2005 for both committees and these were approved by the Supervisory Board.

Audit Committee. This committee, consisting of Mr H.A.D. van den Boogaard (Chairman), Prof W.C. Turkenburg and Mr G.H. Verberg, met twice in 2006. The following topics were covered in these meetings, among other things: pension issues, RJ271, the annual accounts and the management letter, the auditor's report, the new fraud guidelines,

and the structure and functioning of the internal risk-management system.

Remuneration and Appointments Committee.

This committee consists of Mr A. van der Velden (Chairman), Mr R.F.M. Lubbers and Mr L.M.J. van Halderen. The committee met twice in 2006. Topics covered in these meetings included: the regulations and composition of the Supervisory Board, personnel policy, and the remuneration and the objectives of the statutory director.

Conflicting interests. On the basis of the regulations, any conflicting interest of a member of the Supervisory Board, the Board of Directors and the external auditor that is of material significance for ECN or for the person concerned should be reported immediately to the Chairman of the Supervisory Board. No report of this kind was received in 2006. The stipulations set out in the regulations that relate to this were complied with.

Independence. The Supervisory Board believes that the requirement that each of its members, with the exception of one person at most, be independent was complied with. The Supervisory Board considers all the members to be independent.

Changes to the Supervisory Board. The composition of the Supervisory Board did not change in 2006.

The Supervisory Board thanks the Board of Directors and the employees for their efforts and for the results achieved in 2006, which made last year a successful one for ECN.

Rotterdam, 22 March 2007,

The Supervisory Board

Members of the Supervisory Board

Prof. drs. R.F.M. Lubbers

(67, male, Dutch, chairman from June 2005)

- Minister of State
- Chairman U.A.F. Management Board
- Chairman Management Board University of Tilburg
- Chairman Curatorium VNO-NCW
- Chairman International Advisory Board Rotterdam
- Earth Charter
- Worldconnectors
- Ambassador Derde Kamer (NCDO)
- Member/Manager of the management company Breesaap B.V.

Appointment date

First appointment in June 2005. The current appointment runs until June 2009.

H.A.D. van den Boogaard

(67, male, Dutch)

- Chairman of the Board of Supervisory Directors of Grimaflor B.V.
- Member of the Board of Supervisory Directors of ICT Automatisering
- Member Management Board Achmea association
- Chairman Fortis Fonds Barneveld e.o.
- Chairman Barneveld rental housing organisation

Appointment date

First appointment in May 1996. The current appointment runs until June 2009.

Ir. L.M.J. van Halderen

(60, male, Dutch)

- Chairman of the Managing Board of NUON
- Member of the Supervisory Board DRAKA
- Chairman of the Supervisory Board of ISALA-klinieken (Zwolsse hospitals)
- Chairman of the Board of Supervisory Directors of RABO-bank IJsseldelta

Appointment date

First appointment in April 1996. The current appointment runs until June 2008.

Prof.dr. W.C. Turkenburg

(60, male, Dutch)

- Professor of the Department of Science Technology and Society, Faculty of Science, Utrecht University
- Head of the Department of Science Technology and Society, Faculty of Science, Utrecht University
- Scientific Director of the Copernicus Institute for Sustainable Development and Innovation, Utrecht University
- Member of the Board of the International Institute for Industrial Environmental Economics (IIIEE), Lund University, Sweden
- Member of the Board of Directors of the International Energy Initiative (IEI), with regional offices in Bangalore (India) and Sao Paulo (Brazil)
- Member of the Board of the SENSE Research School, Vrije Universiteit Amsterdam
- Chairman of the steering group of the BSIK research programme CATO (CO₂ capture, transport and storage), Utrecht Centre for Energy research
- Member of the Programme Committee for Energy Research at Universities, NWO and SenterNovem
- Member of the Advisory Committee for the scientific journal 'Energy for Sustainable Development', IEI, Bangalore, India
- Member of the Science and Technology Committee for the EU programme CASTOR (Capture and Storage of CO₂)
- Member of the Platform Communication on Climate Change (PCCC), KNMI and MNP, Bilthoven
- Member of the organisational committee for Global Energy Assessment (GEA), IIASA, Laxenburg, Austria
- Member of the Special Committee for Energy Physics (SCEF), Foundation Fundamental Research of Matters (FOM), Utrecht
- Member of the committee Future Energy supplies of the Social Economic Council, The Hague
- Member of the Advisory Committee Basic Research and Innovative Science for Energy (BRISE), European Commission, Brussels
- Member Committee Analysis Nuclear Power Station Borssele, Ministry VROM, The Hague

Appointment date

First appointment in September 2001. The current appointment runs until September 2009.

Ir. A. van der Velden

(66, male, Dutch)

- Chairman of the Board of Supervisory Directors of Vitens N.V.
- Chairman of the Board of Supervisory Directors of Nedap N.V.
- Vice-chairman of the Board of Supervisory Directors of Stork N.V.
- Member of the Board of Supervisory Directors of TKH Group N.V.
- Deputy-chairman of the Commission for EIA
- Member of the Committee on Development Cooperation for the Advisory Board on International Affairs
- Member of the Energy Transition Taskforce

Appointment date

First appointment in February 1996. The current appointment runs until June 2007.

Drs. G.H.B. Verberg

(64, male, Dutch)

- President of the Energy Delta Institute
- Chairman of the Board of Supervisory Directors of Berenschot Holding
- Chairman of the Supervisory Board of the University of Groningen
- Chairman of the Board of Supervisory Directors of UCN N.V.
- Vice-chairman of the Board of URENCO Ltd.
- Member of the Board of Supervisory Directors of Essent N.V.
- Member of the General Energy Council
- Member of the Advisory Board for E.ON Ruhrgas AG
- Member of the General Board of the Prince Bernhard Cultural Fund
- Member of the Supervisory Board of the International Institute for Social Studies, The Hague
- Chairman of the Board of Clingendael Energy Program

Appointment date

First appointment in June 2005. The current appointment runs until June 2009.

Board of Directors

Dr. Ton Hoff - managing director

- Member Committee on Energy, VNO-NCW
- Member Steering Committee “Duurzaamheids-kenniscluster Amsterdam-Noord” (ended 2006)
- Member Advisory Counsel “Syntens” West-Nederland
- Member Task Force Energy Transition of the Ministry of Economic Affairs
- Boardmember EMVT EMVT (ElektroMagnetic High Power Technology)
- Boardmember WEC (World Energy Council), the Netherlands
- Boardmember foundation “Tecnostart”
- Member Dutch Academy of Technology and Innovation
- Member Supervisory Board Foundation Energy Valley
- Vice president, Advisory Group on Energy for 7th Framework Programme, European Commission
- Member Supervisory Board FOM (Foundation for Fundamental Research of Matters)
- Boardmember ATO (Association Technology Transfer)
- Member Advisory Counsel Equens (formerly Interpay)

Dr. Kees van der Klein - adjunct director

- Supervisory Director InDEC b.v. (manufacturer of fuel cell components)
- Supervisory Director Enatec b.v. (development of stirling motors)
- Supervisory Director RGS (development of solar cell components)
- Member Advisory Council Kompetenz-Network Fuel Cells and Hydrogen, Nord Rheinland-Westfalen.
- Chairman Program Advisory Committee of the Energy Forschungszentrum Jülich
- Member Transition Platform New Gas (PNG)
- Chairman Workgroup Hydrogen (PNG)
- Member Transition Platform Sustainable Energy Supply
- Member Advisory Committee on Energy research of NWO/SenterNovem
- Member Executive Board ACTS/NWO
- Member Executive Committee Dutch Separation Technology Institute (DSTI)
- Member Steering Committee BSIK programme CATO
- Boardmember Gas Research And Sustainability Program (GrASp)
- Member Advisory Council Master of Business in Energy Systems Delft TopTech (TU Delft)

Managers Programme Units

- Ir. P.T. Alderliesten, Energy Efficiency in Industry
- Ir. T.J. de Lange, Wind Energy
- Ir. J.R. Ybema, Policy Studies
- Dr. F.A. de Bruijn, Hydrogen & Clean Fossil Fuels
- Dr. ing. J.W. Erisman, Biomass, Coal & Environmental research
- Mrs ir. M.C.C. Lafleur, Energy in the Built Environment & Intelligent Grids
- Dr. G.P. Wyers, Solar Energy

Supporting Services

- Mr. G.P.J. den Hartogh MFM, Facility Services
- Ir. J.J. Saurwalt, Engineering & Services

Staff

- J.M. Bais, Marketing and Innovations (till 1-3-2006)
- Ir. G. Peppink, Programme Secretary
- Dr. ing. J. Prij, Manager General Affairs
- Drs. J.A.G. Stallinga RA, Finances
- Dr. H. Willems, Knowledge Agency
- Ir. J.H.P.C.A. Simons MBA, Personnel and Organisation (till 31-12-2006)
- Mrs. Mr. M.C. Corba, Personnel and Organisation (till 01-07-2007)
- Mr. G. Tunzi, Legal Counsel
- Ing. A.J.M. Schrover, Quality, Safety and Environment

Board of Directors NRG

- Dr. R.J. Stol, General Director
- Ir. A.M. Versteegh, Director

The official annual reports and financial statements of Stichting Energieonderzoek Centrum Nederland for 2006 are prepared in the Dutch language and published as the 'Jaarrekening Stichting Energieonderzoek Centrum Nederland 2006'. We herewith present the latter document in an English translation, which is a true representation of the original, but has no official status from which rights may be derived.

Report from the Board of Managing Directors

1. General

The consolidated financial statements of Stichting Energieonderzoek Centrum Nederland (ECN) comprise the financial statements of ECN and the financial statements of group entities:

- V.O.F. Nuclear Research and consultancy Group (NRG)
- ECN Nucleair B.V.
- Wind Energy Facilities B.V. (WEF) and
- Sunlab B.V.

The mission of ECN is "We develop high-quality knowledge and technology for a sustainable energy economy and take these to the market".

ECN, being a private-law institution, is a task institute with a unique position in Europe in the area of sustainable energy. Its high-quality research infrastructure enables it to (further) develop or exploit knowledge and innovative technology. ECN wishes to perform groundbreaking research to add advantage to the energy transaction. By participating intensively in the transition process, ECN wishes to provide active counter play in the "innovation paradox" observed by Wijffels: high-quality knowledge and technology development against a comparatively poor flow through into effective applications.

The research activities of ECN are primarily long-term demand-driven programs, devised in close cooperation with the Ministry of Economic Affairs and SenterNovem. The leading principle is increasing the synergy in subject matter between the EZS research programme and EOS commissions.

The research activities in the area of nuclear technology have been organised under the Nuclear Research and consultancy Group VOF (NRG) since 1998. As knowledge centre, NRG has acquired a good position within the relevant international science community. Spearhead is the development of knowledge, products, and processes for safe applications of nuclear technology for energy, the environment, and health.

The activities of the Wind Energy Facility B.V. focus on the exploitation of a test park for megawatt wind turbines. This is research into specific effects of mutual so-called "ZOG effects" on the wind turbines installed in this park, the re-delivery of the energy created through these effects, and the leasing of testing room to third parties for the placement of own prototypes wind turbines. The wind turbines were sold and leased back in a transaction with NIB Capital at year-end 2003.

On 17 December 1998, ECN and KEMA Nucleair B.V. (KEMA) concluded a Joint Venture Agreement, setting up V.O.F. Nuclear Research and consultancy Group. The equity participations of the partners ECN and KEMA are 70% and 30% respectively. On 1 December, ECN acquired the shares of KEMA Nucleair B.V., and the name of the entity changed into ECN Nucleair B.V. with statutory seat in Petten. NRG is now wholly owned by ECN.

2. The situation as at balance sheet date

In terms of finances, two events had an impact on financial year 2006. ECN operated financially successfully in 2006. However, the solution to the pension question was such a financial sacrifice, that the balance was negative result of € 945,000. The increase from € 107 to € 121 million in the sum of income from

operations was largely due to additional EOS financing, and a higher number of commissions from third parties. Not all vacancies could be filled, so that employees charged a higher number of billable direct hours to generate this income.

Secondly, management and the employees agreed to transfer their pension rights to the ABP from 1 January 2007. The overdue indexation of back-service obligations for former employees and back-service obligations for current employees for the years 2003/4/5 and 6 was paid for.

The cash in bank and at hand is unusually high at € 66 million. This is largely due to a payment of € 8 million from the Ministry of Economic Affairs (EZ) in the Escrow account to supplement the € 15 million EZ paid in 2004 for the financing of the disposal of Radio Active Waste. ECN leads a number of 6th framework projects and manages third-party assets to the sum € 5 million. EZ paid approximately € 10 million in 2006 as an advance payment to finance the first quarter 2007, and NRG received approximately € 12 million in advance for specific assignments. Concluding from the above, of € 66 million cash, ECN merely has the disposal of € 13 million.

These developments caused the balance total to increase more than 20%. Taking into account the acquisition of the Kema Nucleair B.V. and the loss of € 945,000, the debt-to-equity ratio is evident. The debt-to-equity ratio fell from more above 8% to above 5%.

NRG and EURATOM concluded an agreement for HFR operations in the period 2004 through 2006 based on the Supplementary HRF Programme of the EU. The contemplated Joint Undertaking to organise the role of the Supplementary HFR Programme in the HFR operations is delayed. The Supplementary Programme 2004/2006 has now been extended one more year, so that the Joint Undertaking can start working in the course of 2007. The discussions with possible participants in the Joint Undertaking produced some concrete results.

The number of employees ECN employed at year-end 2006 increased by 21 persons compared to year-end 2005, from 885 (NRG 302) to 906 (NRG 315). The number of FTE rose from 808 (NRG 280) at year-end 2005 to 833 (NRG 286) year-end 2006.

3. Developments during the financial year

Starting in 2006, the Ministry of Economic Affairs and ECN made new arrangements on the subject "Synergy ECN and energy research". This was the outcome of the recommendations by the Wijffels committee in 2005. The newly agreed working method allocates certain parts of the energy research program to ECN directly. For the other parts, ECN is to work in cooperation with consortia. There are also research areas for which ECN can tender together with competitors in regular tenders. ECN will benefit from these reorganisations, because it can avoid uncertainties and costs from tender procedures and inconsistencies in programs.

In 2003, the boards of managing directors of ECN and NRG announced to their staffs that the existing pension plan, based on an unconditional, indexed defined benefit plan was no longer feasible for financial reasons. At the request for Former Employees ECN & NRG (OMEN), the Court of Alkmaar decided their action on 26 July 2006. The Court ordered ECN and NRG to pay overdue indexations on currently payable pensions and surrendered pension rights for the years 2003, 2004, and 2005. The payable lump sums under the order were remitted to the pension insurer in 2006.

Management and the two works councils (ECN and NRG) and the unions reached agreement by the end of 2006 on a new pension regulation at ABP starting from 1 January 2007, based on average earning benefits and a conditional indexation. The agreement also provided that the pension rights accrued until year-end 2006 be surrendered and remain with insurer Centraal Beheer Achmea. ECN and NRG have remitted additional amounts for the indexation payable on these rights over 2006.

The payment of the indexation will end the legal dispute between OMEN, ECN, NRG, and KEMA on the payment of indexation over 2003. The changed wording of the indexation clauses effective from 1 January 2007 in the new pension regulation was unilaterally settled

after several compromise efforts, to avoid differences between pension rights of active participants and sleeping participants." OMEN announced that it might take legal action against this settlement.

After changes in the law preventing the application the current FLO regulation, management reached agreement with interested parties on a new regulation, linked to the life-cycle savings regulation. It submitted the proposal to the Tax Administration for approval.

4. Results

The new pension regulation provides that the earlier pension regulation including indexation be fully financed up to 31 December 2006. The aggregate non-recurring additional burden was approximately € 11 million.

The above is stated in the profit and loss account under staff costs, which are much higher than usual. A positive effect of unfilled vacancies was that the other ECN employees booked more billable hours. There was also a one-time accrual of approximately € 3.4 million from exercising the (Indec) put option.

5. Expectations for 2007

The ECN management is positive in its outlook for 2007. Management is expecting at least to equal the 2006 sum of income from operations in 2007. A proviso to this outlook is that ECN management will be successful in filling the vacancies. A positive development is that the ratio of foreign (temporary) employees is increasing due to ECN's broadening horizon.

At the end of the financial year, management agreed with the works councils and the trade unions to transfer to ABP and accept a new pension regulation. Management has undertaken that pension rights accrued at Centraal Beheer Achmea up to 1 January 2007, with the exception of pension rights based on the pension regulation of 1964 (rights with a fixed 3% increase annually), will be indexed every year. Besides a fixed annual payment of € 2 million during a period of 10 years (the indexation for 2006 was provided for), a variable part of the profit will be paid into the fund remaining with CBA.

Normalised net profit for 2007 is expected to rise. However, net profit in the coming years will be less favourable due to the aforementioned variable contributions.

Starting in 2007, the management intends to raise the investment level, to be able to realise a laboratory infrastructure in one of the buildings. A new radiological laboratory will be delivered in 2007. Facilities management will start a major maintenance programme on buildings. A large amount of preliminary work was done in 2006 for these improvements. The organisation structure will be on the agenda following the legal restructuring due to the acquisition of Kema (30%) in NRG.

The current financing of ECN is adequate and enables ECN to perform its operational work to satisfaction.

"The hectic surrounding the pension problem has disappeared."

The year 2006 was from a financial point of view a turbulent year due to the substantial amounts that had to be paid in order to solve the different points of view with respect to the indexation of the pension rights up to and including 2006. As of January 2007 the new pension contract with ABP offers more certainty with respect to continuance in the building up of pension rights than before.

Besides the problem concerning the pensions, ECN in 2006 was confronted with new financial administration regulations with regard to the financing of the various projects. As well as orders from the Netherlands, ECN acquired more orders from other European countries, predominately through the European Union. The financial administration and demands from our customers differ from one to the other. Our financial information system now enables us to handle these more complex rules and regulations and enables us to implement the rules to everyone's satisfaction.

Jan Stallinga
Head of the Finance Department



Jan Stallinga

Consolidated balance sheet as at 31 December (in € x 1000)

Assets			Liabilities		
	2006	2005		2006	2005
Fixed assets			7 Group equity		
1 Intangible fixed assets	87	11	Equity	8,812	9,757
2 Tangible fixed assets	24,852	25,234	Minority interest	41	1,331
3 Financial fixed assets				8,853	11,088
·Particip. in knowledge-based companies	796	928	Provisions		
·Other participations	33	45	8 Provision for Early Retirement (FUT)	0	0
·Securities	25,283	25,536	9 Provision for redundancy	736	1,590
·Other receivables	6,420	7,415	10 Prov. for transitional law pension regulations	0	4,400
	32,532	33,924	11 Provision for pension indexation	14,215	0
Total fixed assets	57,471	59,169	12 Provision compensation at the start of retirement	2,306	0
Current assets			13 Provision for functional redundancy FLO	4,564	2,317
4 Work in progress	14,158	12,236	14 Provision for anniversary disbursement	1,048	1,014
5 Receivables and prepaid expenses	20,006	15,857	15 Provision for radioactive waste	56,499	54,316
Inventory	6,238	4,467	16 Provision for work in progress	1,562	3,116
	40,402	32,560	Other provisions	4,802	4,909
6 Cash at bank and in hand				85,732	71,662
Delta Lloyd Bank NV	0	7	17 Current liabilities		
In hand	7	3	Deferred income third parties	31,937	15,281
ING/Postbank	44,921	29,100	Accounts payable	10,701	8,625
ABN/AMRO	21,407	12,650	Taxation	1,971	2,071
	66,335	41,760	Other social security charges & personnel costs	8,027	6,664
Total	164,208	133,489	Liabilities for pensions	8,306	11,390
			Other liabilities and accrued expenses	8,681	6,708
				69,623	50,739
			Total	164,208	133,489

Consolidated statement of income in 2006 (in € x 1000)

	2006	2005
Operating income		
Income		
18 · Financing by the State of the Netherlands	44,580	36,922
19 · Third party income	65,054	60,664
· Increase/decrease in work in progress	3,214	833
	68,268	61,497
20 Capitalised corporate production	1,825	2,188
21 Other operating income	7,162	6,261
Total operating income	121,835	106,868
Operating expenses		
22 Wages and salaries	51,773	47,920
Social security contributions	2,472	3,277
Pension charges	20,641	8,108
Depreciation of intangible fixed assets	1	7
Non-rec. impairment of intangible fixed assets	810	0
23 Depreciation of tangible fixed assets	4,090	5,199
24 Other operating expenses	44,928	37,294
Total operating expenses	124,715	101,805
Operating income	-2,880	5,063
25 Financial income and expenses	-820	-381
Result on ordinary operation before tax	-3,700	4,682
26 Taxation on result from ordinary operations	-583	-353
Result on ordinary operation after taxation	-4,283	4,329
Share in results of participations	3,338	536
Minority interest in group result	0	-/-446
Net result	-945	4,419

Consolidated cash flow statement (in € x 1000)

	2006	2005
Cash flow from operating activities		
Operating result	-2,880	5,063
Depreciation of tangible fixed assets	4,090	5,199
Depreciation of intangible fixed assets	1	7
Non-recurring impairment on intangible fixed assets	810	0
Addition/allocation of reserve	14,070	4,747
Movement in working capital		
- Work in progress	-1,922	-1,070
- Receivable and inventory	-1,771	-4,242
- Accounts payable	-4,149	-261
- Other liabilities	18,884	2,084
	11,042	-3,489
Cash flow from operating activities	27,133	11,527
Financial income and expenses	-820	-381
Profit tax	-583	-353
	-1,403	-734
Cash flow from operating activities	25,730	10,793
Movements in intangible fixed assets	-87	19
Disposals of intangible fixed assets	10	0
Investment tangible fixed assets	-5,317	-4,813
Disposal of tangible fixed assets	1,609	1,069
Acquisition of group companies	-2,100	-973
Alienation of non-consolidated participations	3,482	131
Movements in fin. fixed assets excl. participation	253	1,194
Movement in other receivables	995	-592
Cash flow from investment activities	-1,155	-3,965
Cash flow from financing activities	0	0
Net cash flow	24,575	6,828
Starting balance cash	41,760	34,932
Closing balance cash	66,335	41,760
Movement in cash	24,575	6,828

General

Unless indicated otherwise, all amounts stated in the annual report are x € 1,000. Stichting Energieonderzoek Centrum Nederland [Energy research Centre of the Netherlands] (ECN) has its registered office in Petten, municipality of Zijpe, the Netherlands.

For the Stichting's object, reference is made to Article 3 of the Articles of Association, which reads: "The object of the Stichting is to gain knowledge and experience in the field of energy and to ensure that it is effectively made instrumental to the public interest and the various sub-interests to be distinguished therein."

Activities

The activities of Stichting Energieonderzoek Centrum Nederland, with its registered office in Petten, the Netherlands, and its group companies consist primarily of:

- a. conducting and commissioning fundamental, strategic, and applied research and related studies in fields determined by the Stichting itself, or as instructed by the national government, lower government authorities, companies, including electricity companies, other organisations and individuals.
- b. making accessible and sharing the results of research and studies as referred to under a., and supervising and providing support in the application of those results.
- c. collaborating with companies, included energy companies, and other research institutions in research and studies as referred to under a.
- d. contributing to coordinating research and studies in the Netherlands, and collaboration internationally.

Group structure

Stichting ECN heads a group of companies. Please see note 3 to the consolidated balance sheet for an overview of the information required under Sections 379 and 214 Book 2, of the Dutch Civil Code.

Mergers and acquisitions

On 1 December 2006, ECN acquired all the equity of ECN Nucleair B.V. (predecessor KEMA Nuclear B.V.) ECN Nucleair B.V. holds a 30% participating interest in V.O.F. Nuclear Research Group, so ECN now wholly owns NRG. Former shareholder of ECN Nucleair B.V. waives dividend payment relating to the financial year 2006 in the purchase agreement. The results of ECN Nucleair B.V. are fully included in the consolidated financial statements of ECN as from 1 January 2006.

Principles of consolidation

The consolidated financial statements of Stichting ECN include the financial statements of the group companies, and other legal entities over which Stichting ECN has management control, or are managed centrally. The consolidated financial statements are prepared in accordance with the principles for the valuation and determination of result of Stichting ECN.

The financial statements of the group companies, and other legal entities and companies included in the consolidation, have been fully included in the consolidated financial statements. All intercompany relationships and transactions have been eliminated. Minority interests in Stichting ECN's equity and the results of group companies are reported separately in the consolidated financial statements.

The results of newly acquired group companies and the other legal entities and companies included in the consolidation are consolidated as from the date of acquisition. On that date, the assets, provisions, and liabilities are valued at real values. The paid goodwill is charged fully to the result in the year of acquisition of the entity. The results of divested participations are included in the consolidation until the date the group affiliation is terminated. The consolidated financial statements for 2006 comprise the financial statements of ECN, the group companies NRG vof, ECN Nucleair BV, Wind Energy Facilities B.V. (WEF) and Sunlab BV, all having their registered offices in Petten, municipality of Zijpe, the Netherlands. All intercompany receivables, debts, and transactions have been eliminated in the financial statements. ECN holds 100% of the shares in ECN Nucleair BV, WEF BV, and Sunlab BV at year-end 2006. Apart from NRG, ECN Nucleair BV, WEF BV, and Sunlab BV, ECN holds a number of other participations with

a majority shareholding. These participations are not included in the consolidation because of their insignificant financial impact on the consolidated financial statements.

General principles for the preparation of the consolidated financial statements

The consolidated financial statements have been prepared in accordance with the provisions in Title 9, Book 2, of the Dutch Civil Code. The valuation of assets and liabilities and the determination of the result are based on the historical cost convention. Assets and liabilities are recorded at face value, unless another basis is stated for the specific balance sheet item. Income and expenditures are recognised in the year to which they relate. Profits are recorded only to the extent they were realised on the balance sheet date. Liabilities and possible losses originating before the end of the year under review are recorded if they were identified before the financial statements were prepared.

Financial system changes

As from 1 January 2006, the difference between the purchase price of acquired participations and the value based on net asset value (goodwill) is capitalised, and charged to the result in one step. In former years, the goodwill paid on acquisitions was capitalised and depreciated on its useful life. Under the valuation principles of the Stichting, effects from financial system changes are recognised as separate items in the equity of the stichting. By 1 January 2006, the goodwill paid in the past was fully depreciated. Therefore, the effect of this financial system change is negligible. The acquisition of new participations in the financial year has had a negative effect of EUR 810 on the results 2006.

ECN acquired the entity ECN Nucleair BV (formerly KEMA Nuclear BV) on 1 December 2006, and through this transaction, it acquired KEMA's (30%) participating interest in NRG. The acquisition price was EUR 2.100, including goodwill of EUR 810. This amount was charged to the result as non-recurring value impairment.

Financial instruments

Financial instruments include primary financial instruments, such as receivables and debts and derivative financial instruments. For the principles of primary financial instruments, we refer to the classification of each balance sheet item. The Stichting has not covered the incurred exchange and interest risk with derivative financial instruments in the financial year 2006

Changes in the presentation.

To facilitate comparison, the figures for the 2005 financial year have been modified where necessary to be in line with the presentation used for the 2006 financial year.

Translation of foreign currencies

Receivables, debts, and obligations in foreign currencies are translated at the exchange rates prevailing at the balance sheet date. Transactions in foreign currencies during the year under review are recognised in the financial statements at the exchange rates prevailing at the transaction date. The exchange differences resulting from the translation as at the balance sheet date included in the statement of income, taking into account any hedge transactions.

Valuation principles of assets and liabilities

Intangible fixed assets

Intangible fixed assets are stated at cost incurred, less the cumulative depreciations and, if applicable, impairments. Annual depreciation is based on the straight-line method over a period of five years.

Tangible fixed assets

Tangible fixed assets are stated at the acquisition price, less cumulative depreciations and, if applicable, impairments. Depreciation is based on estimated useful life, calculated as a fixed percentage of the acquisition price, allowing for residual value. Depreciation commences when the asset is first used. Land is not depreciated.

Depreciation is based on the straight-line method for the following terms:

- Buildings 20 years
- Temporary buildings and land facilities 10 years
- Installations and fixtures 10 years
- Instruments, machinery, etc. 5 years
- Computer equipment and software 3 years

ECN acquired the site in long-term lease from the Dutch Forestry Commission in 1957. The lease term was extended in 1996 from 2007 to 2032.

Financial fixed assets

The non-consolidated participations in which Stichting ECN has significant influence on the business and financial policies are valued at net asset value, but not lower than nil. The net asset value is determined according to the valuation principles of Stichting ECN.

Participations with negative net asset value are valued at nil. If the Stichting fully or partly guarantees the debts of the relevant participation, a provision is created, charged primarily to the receivables from this participation and, for the rest, under the provisions for the share in the participation's losses, or for the amount of the Stichting's loans to these participations.

Participations in which the Stichting has no significant influence on business and financial policies are valued at acquisition price and deduction for impairments if indicated. Capital interests of a durable nature, other than participations, are valued at the lower of cost or market value. The receivables from and loans to participations as well as other receivables are included at face value and deduction of any provisions deemed necessary.

The securities included under the financial fixed assets are valued (per fund) at the lower of cost or market value as at the balance sheet date. The bonds are valued at the lower of cost or market value as at balance sheet date, with the premium or discount upon the acquisition of bonds, divided across their terms, charged, or added to the result.

Inventory and work in progress

Inventory of raw and ancillary materials and trade goods are valued at the average acquisition price, with deduction of provisions deemed necessary for stock obsolescence.

Work in progress is valued at cost incurred, less the amounts already stated on the balance sheet date and losses already foreseeable on the balance sheet date. The costs incurred include the direct use of materials, the direct wage and machinery costs and other costs that are directly attributable to the research project. The income from the financing of the research project is determined based on the costs incurred in connection with the work at the balance sheet date.

Receivables and prepaid expenses

Receivables are included at face value, minus provisions deemed necessary for the risk of bad debts. These provisions are based on an assessment of individual receivables.

Provisions

In 2006, the pension regulation changed, changing the nature of the pension regulation from a defined benefit regulation into a defined contribution regulation. For this reason, the valuation as in the financial statements for 2005 no longer applies.

Other provisions:

- Provision for radioactive waste:

This provision is for the costs of future treatment and storage of radioactive waste. This provision is determined at face value, included 5% interest to cover future price increases.

- Major maintenance:

The provision for equal distribution of charges due to major maintenance on buildings is determined based on expected costs over a se-

ries of years. The provision is usually set up according to the straight-line method, but was increased after a third-party (Temid) reported overdue maintenance. The maintenance performed is deducted from this provision.

Principles for determination of the result

Operating income

Operating income includes income from services and products provided in the year under review, less the taxation of the turnover. Income from research projects is included in proportion to progress made. Costs for these research projects are recognised in same period they are incurred.

Taxes

Corporate income tax is determined by applying the respective rate to the result for the financial year, taking into account permanent differences between profit calculations according to the financial statements and those for tax purposes.

Share in the result of non-consolidated companies

The result of participations in which the Stichting exercises significant influence on business and financial policies is stated as the share in the profit of these participations to which the Stichting is entitled. This profit is determined in accordance with the principles for valuation and determination of the result applicable at Stichting ECN. For participations in which no significant influence is exercised on business and financial policies, the dividend is regarded as result. It is included under financial income and expenses.

Principles for the preparation of the consolidated cash flow statement

The cash flow statement is prepared according to the indirect method. The cash in the cash flow statement consists of cash and cash equivalents.

Fixed assets**1 Intangible fixed assets**

At WEF BV, the superficies for the “Transformator station” asset were capitalized. Based on a tax settlement (transfer tax), the purchase value was adjusted downward in 2005. SunLab BV developed a sphere scanner in 2006, which it expected to be taken to the market early in 2007.

Intangible fixed assets are specified as follows:

	Superficies	Movement	Total 2006	Total 2005
Purchase price				
At 1 January 2006	18	0	18	37
Investments	0	87	87	0
Disposals	-18	0	-18	-19
At 31 December 2006	0	87	87	18
Depreciation				
At 1 January 2006	-7	0	-7	0
Depreciation during FY	-1	0	-1	-7
Disposals	8	0	8	0
At 31 December 2006	0	0	0	-7
Book value				
At 1 January 2006	11	0	11	37
Investments	0	87	87	0
Disposals	-10	0	-10	-19
Depreciation during FY	-1	0	-1	-7
At 31 December 2006	0	87	87	11

2 Tangible Fixed Assets

	Buildings and land	Industrial installations and fixtures	Instru- ments and machinery	Fixed assets in progress	Total 2006	Total 2005
Purchase value						
At 1 January 2006	42,190	41,808	52,183	1,704	137,885	134,416
Investments	400	87	1,908	1,837	4,232	4,813
Transfers	90	219	829	-1,138	0	0
Disposals	-106	-261	-188	0	-555	-1,344
At 31 December 2006	42,574	41,853	54,732	2,403	141,562	137,885
Depreciation						
At 1 January 2006	-27,673	-36,574	-48,404	0	-112,651	107,727
Depreciation during FY	-1,654	-919	-1,517	0	-4,090	5,199
Disposals	0	0	31	0	31	-275
At 31 December 2006	-29,327	-37,493	-49,890	0	-116,710	112,651
Book value						
At 1 January 2006	14,517	5,234	3,779	1,704	25,234	26,689
Investments	400	87	1,908	1,837	4,232	4,813
Transfers	90	219	829	-1,138	0	0
Disposals	-106	-261	-157	0	-524	-1,069
Depreciation during FY	-1,654	-919	-1,517	0	-4,090	-5,199
At 31 December 2006	13,247	4,360	4,842	2,403	24,852	25,234

3 Financial fixed assets

	2006	2005
Balance as at 1 January	973	568
· Debit: Disposals	-407	-17
· Debit: Sunlab (due to consolidation)	0	-161
· Credit: Investments	1	0
· Credit: Results of participations	262	583
Balance as at 31 December	829	973

Participations in knowledge-based enterprises

	Address	ECN share at year-end	2006 Euro	2005 Euro
		%		
· ENATEC BV	Zevenaar	12.8	0	0
· RGS BV	Petten	30.0	756	480
· SWEAT BV	Duiven	33.3	23	36
· SUNDYE BV	Petten	100.0	16	16
· INDEC BV	Petten	0 / (36.5)	0	396
· ASTER INTELLECTUAL PROPERTIES BV	Veessen	20.0	0	0
· SOLSILC DEVELOPMENT COMPANY	Trontheim	10.0 / 0	1	0
Total as at 31 December			796	928

Other participations

	Address	ECN share at year-end	2006 Euro	2005 Euro
		%		
· DNC Nuclear Technology BV	Arnhem	100.0	18	18
· ToN2*	Petten	100.0	15	16
· ENERSEARCH AB	Malmö	0 / (12.5)	0	11
· SULPHCATCH BV	Petten	80.0	0	0
Total as at 31 December			33	45

*ECN International BV is named ToN2 BV as from December 2006.

Securities

The movement of this portfolio is as follows:

	2006	2005
Balance as at 1 January	25,536	26,730
· Debit: Sales	-228	-7,799
· Credit: Purchases	383	6,583
· Credit: Exchange differences	-408	-253
Balance as at 31 December	25,283	25,536

Bonds are pledged to the maximum value of the credit facility extended by ING Bank, for € 15,000. The other securities are at the free disposal of ECN. The bond portfolio has a face value of € 22,407 (2005: € 22,407). The market value is € 20,110 at year-end 2006 (2005: € 21,143). The market value of the shares portfolio is € 6,364 at year-end 2006 (2005: € 6,114).

Movement in securities portfolio according to type:

	Bonds	Shares	Total
Balance at 1 January 2005	20,170	5,366	25,536
· Debit: Sales	0	-228	-228
· Credit: Purchases	0	383	383
· Credit: Exchange differences	-347	-61	-408
Balance at 31 December 2005	19,823	5,460	25,283

Other receivables

This item includes the receivable from Tyco regarding the payable lease terms for Molybdeen. The basis is an investment of € 20 million and a contract for 20 years. The remaining outstanding receivable at year-end 2006 is € 6,943. In 2007, an amount of € 523 will be repaid. This amount is included under current assets.

The movement of the Other receivables is as follows:

	2006	2005
Balance as at 1 January	7,415	6,823
· Investments	146	1,163
· Repayments	-618	-571
· Transfer to current liabilities	-523	0
Balance as at 31 December	6,420	7,415

Current assets

4 Work in progress

	2006	2005
Recap:		
Work in progress	14,158	12,236
Provision for work in progress *)	-1,562	-3,116
Balance as at 31 December	12,596	9,120

*) This provision is included in the balance sheet as credit.

5 Receivables and prepaid expenses

Receivables and prepaid expenses are stated at face value after deduction of required provisions.

They expire within one year and comprise:

	2006	2005
Summary		
Trade debtors	14,513	11,423
Receivables from participations	444	635
Other receivables	5,049	3,799
Balance as at 31 December	20,006	15,857

Inventories

Inventories are valued at cost, adjusted for obsolescence if necessary.

6 Cash

Cash is freely disposable, with the exception of € 52,908, being the Escrow account with advanced funds KP6 projects (EU), advanced EZ funds 2007, funds advanced to NG for projects and the sale and lease back obligation WEF). The bonds are pledged to the maximum value of the credit facility extended by ING Bank, which is € 15,000. A credit facility of € 4.5 million is available at ABN AMRO, for which no security has been provided.

7 Group equity

Reference is made to the notes on equity in the statutory financial statements.

Provisions

The provisions below mostly have a long-term nature.

8 Provision for early retirement (FUT)

This provision is related to the early-retirement regulation of 1 July 1999 and the termination of the so-called FUT early retirement regulation effective up to that time. There are no more obligations for FUT benefits from 1 January 2006.

The provision comprises:

	2006	2005
Balance as at 1 January	0	9
· Debit: withdrawal	0	-9
· Debit: release	0	0
· Credit: interest compensation	0	0
Balance as at 31 December	0	0

9 Provision for redundancy costs

This provision is intended to cover costs of staff redundancies ensuing after reorganisations. As in previous years, the annual interest compensation was based on 5%.

The movement of this provision is as follows:

	2006	2005
Stand per 1 januari	1.590	2.810
· Debit: withdrawal	-494	-1.242
· Debit: release	-425	-395
· Credit: addition	0	300
· Credit: interest compensation	65	117
	-854	-1.220
Balance as at 31 December	736	1.590

10 Provision for transitional law related to pension regulation

This provision is based on transitional law which prescribes compensation of differences between the pension regulation dated 1 July 1999 as against the former pension law. The transitional law is effective up to 2018. This obligation was replaced in 2006 by the new pension regulation at ABP, effective from January 2007 and the surrendering of the pension regulation at Centraal Beheer Achmea at year end 2006. The balance of the provision was added to current liabilities under Payable to Centraal Beheer Achmea. See also part 12.

The movement of this provision is as follows:

	2006	2005
Balance as at 1 January	4,400	4,617
· Debit: withdrawal	0	0
· Debit: reclassification	-4,400	0
· Debit: release	0	-448
· Credit: addition	0	0
· Credit: interest compensation	0	231
	-4,400	-217
Balance as at 31 December	0	4,400

11 Provision for the indexation of pensions

The (surrendered) pension rights, accrued up to year-end 2006 by both active participants and former participants were deposited with Centraal Beheer Achmea (CBA), and will remain insured by the latter. Effectively, the nature of the pension obligation in the form of "contributions to be paid to CBA"; this means it is not a self-administered pension obligation. With the exception of the pension rights based on the pension rules of 1964 (the pension rights with a fixed 3% annual increase), ECN and NRG will annually index the aforementioned pension rights. The indexation will be financed separately from the new pension regulation at ABP and is conditional. The pension regulation aims at indexation at price index level, but is limited to what can be achieved in any year with the disposable financial resources. For this reason, the indexation clauses in the various pension clauses have been amended (unilaterally). This indexation method is applied to achieve a near market-level result within the limited financial means.

To finance the indexation, the following financing is available, and/or ECN/NRG will make the following financing available.

- For a period of 10 years, ECN/NRG will pay a fixed amount of € 2 million into the deposit each year.
- For a period of 10 years, a preferential allocation of the result of € 1 million will be paid into the deposit each year. This allocation is conditional to sufficient positive result. If the positive result is smaller than € 1 million, the full amount of the result will be transferred to the deposit.
- For a period of 10 years, 1/3 of a positive result between € 1 and € 4 million will be paid into to deposit each year. This payment is conditional to the result being more than € 1 million.

- For a period of 10 years, a payment of half of the positive result above € 4 million will be paid into the deposit each year. This payment is conditional to the result being more than € 4 million. Result is defined a net consolidated result after taxes.

Based on a discounted cash flow analysis, at 5% interest, € 16,215 million must be reserved for the fixed payment of € 2 million at consolidated level. The ratio in the provision between ECN (82.34%) and NRG (17.66%) is based on the ratio in the deposit. This ratio will not be revised. The obligation for 2007 has been stated under current liabilities (see "debts for pensions").

The movement of this provision is as follows:

	2006
Balance as at 1 January	0
· Debit: reclassification	-2,000
· Debit: release	-
· Credit: addition	15,997
· Credit: interest addition	218
	14,215
Balance as at 31 December	14,215

The withdrawal of € 2,000 arises from a reclassification into a current liability in the balance sheet at year-end 2006.

12 Provision compensation on commencement of retirement

Article 24, paragraph 7 of the pension regulation 1999 on the compensation on commencement of retirement continues to be effective under Transitional law, effective from 2000 to 2018.

This compensation is based on a graduated scale varying from 3 monthly salaries in 2000 to 1.25 monthly salaries in 2018 on commencement of retirement. Under the same tax limitations applying to anniversary and redundancy disbursements, this compensation is paid to employees who retire straight after employment. In 2005, this provision was part of the provision Transitional law pension regulation, see part 10. This provision has now been split into a part that is added to current liabilities for the settlement with Centraal Beheer Achmea at year-end 2006. The item compensation on commencement of retirement is now taken to this provision.

	2006
Balance as at 1 January	0
· Debit: withdrawal	0
· Debit: release	0
· Credit: reclassification	2,306
· Credit: interest addition	0
	2,306
Balance as at 31 December	2,306

13 Provision FLO

Employees working in shifts were entitled to the Functional Age Discharge regulation (FLO) as from the age of 57.5. Due to changes in law, this regulation is no terminated. A new regulation has been agreed in consultation with the respective employees. This regulation provides in the accrual of leave under the life-cycle savings regulation, enabling an accrual of a personal budget of 210% of the employee's salary. In addition, a transition regulation has been provided for current employees. The new regulation was accepted by all the parties on condition that the Tax Administration approves the regulation. Consultations with the Tax Administration are underway. An additional € 1,913 besides the normal addition of € 340 has been added to the provision to provide for the new regulation. The withdrawal in 2006 related to employees who qualified under the preceding regulation in 2006.

The movement of this provision is as follows:

	2006	2005
Balance as at 1 January	2,317	2,044
· Debit: withdrawal	-127	-257
· Credit: addition	2,253	435
· Credit: interest compensation	121	95
Balance as at 31 December	4,564	2,317

14 Provision related to anniversary disbursement

This provision is intended for future anniversary disbursements.

The movement of this provision is as follows:

	2006	2005
Balance as at 1 January	1,014	0
· Debit: withdrawal	-53	0
· Credit: addition	53	1,014
· Credit: interest compensation	34	0
Balance as at 31 December	1,048	1,014

The provision remained unchanged compared to 2005 except for the addition of interest, as the employees who are to benefit from this provision have hardly changed.

15 Provision for radioactive waste

This provision is intended for the costs of future treatment and storage of radioactive waste.

The movement of this provision is as follows:

	2006	2005
Balance as at 1 January	54,316	52,756
· Debit: withdrawal	-1,313	-1,344
· Credit: addition	766	260
· Credit: interest compensation	2,730	2,644
Balance as at 31 December	56,499	54,316

16 Other provisions

Building Maintenance Provision

The movement of this provision is as follows:

	2006	2005
Balance as at 1 January	3,371	1,031
· Debit: withdrawal	-752	-1,033
· Debit: release	0	-300
· Credit: addition	700	3,673
Balance as at 31 December	3,319	3,371

Based on the findings of the investigation performed by DGV/TEMID, an addition was made in 2005 to cover the costs of the overdue maintenance that was found. The FTE available in 2006 was insufficient to catch up on the backlog. This matter will receive more attention in the next financial year.

Provision for Work in Progress and other provisions

The provisions for 'Building Maintenance', Lead Cells' and 'DWT sludge storage' have been included under other provisions. In addition, there is a separate provision to correct Work in progress, to cover a possible risk of a cost overrun in current projects.

	OHW	Lead cells	Storage sludge DWT	Other	Misc. in 2006
Balance as at 1 January	3,116	545	493	500	1,538
· Debit: withdrawal	-1,554	0	0	0	0
· Credit: addition	0	0	26	119	145
· Credit: interest comp.	0	0	0	0	0
· Debit: release	0	0	0	-200	-200
Balance as at 31 December	1,562	545	519	419	1,483

17 Current liabilities

Current liabilities are specified as follows:

	2006	2005
1. Deferred income from third parties	25,512	15,281
2. Accounts payable, deliveries & services third parties	10,701	8,625
3. Taxation		
- Corporate income tax	455	353
- Turnover tax	-139	264
- Wage tax	1,655	1,454
4. Other social security charges and personnel costs		
- Pension charges	8,306	11,390
- Reservation for holiday allowance & leave balances	6,038	5,447
- Other personnel charges	1,989	1,217
5. Other liabilities and accrued expenses		
- Payable to co-contracting parties in projects	6,425	3,092
- Deferred payments related to the storage of uranium filters	494	973
- Funds advanced for 6th framework accounts	4,995	2,626
- Other liabilities	3,192	17
Balance as at 31 December	69,623	50,739

Current liabilities are to be settled within a single financial year.

Obligations not apparent from the balance sheet

Obligations

- ECN received funds from the Ministry of Economic Affairs to pay for future work related to the disposal of radioactive waste. The payments from the Escrow account that has been opened for this purpose may be solely be remitted, if the payment orders are signed by both parties (EZ and ECN). If due to circumstances, ECN is not able to perform the work itself, or commission the work to third parties under its supervision, it is obliged to repay the non-disbursed amount to the Ministry of Economic Affairs.
- As a partner to the partnership firm NRG and WTW, stichting ECN is jointly and severally liable for the debts of the partners.
- The site was acquired in 1957 through a long-term lease from the Dutch Forestry Commission. In 1996, the lease term was extended from 2007 to 2032. Under the contract, ECN can apply for a further extension of 20 years up to 2052, provided it submits the application before 1 January 2008. The annual ground rent was set at € 194 per year in 2003, to be indexed annually by 3%. The annual ground rent in 2006 was € 204.
- During the financial year 2003, ECN Wind turbine Test park Wieringermeer CV, wholly-owned by Wind Energy Facilities BV, itself a wholly-owned subsidiary of ECN, entered into a sale and lease-back agreement to finance a wind turbine testing field in which large wind turbines will be tested for offshore locations. The ensuing lease payable is € 1,632 per year, from 2004 to 2012 (as stated in e).

e) Specification of contractual obligations undertaken:

Description	< 1 year	> 1 yr < 5 yrs	> 5 years
Rent for Arnhem M01 and M05	433	0	0
Rent for Arnhem B48	118	354	0
Car leases	195	117	0
NIB lease obligation (WEF BV)	1,632	6,528	3,264
Scale park lease ECN – WEF	180	720	0
Nashuatec	170	600	83
Asito	400	0	0
Pre Ned Beveiliging	711	2	0
	3,839	8,321	3,347

f) In financial year 2006, former ECN employees filed a claim for indexation of pensions, which was awarded by the Alkmaar District Court. Thereafter, the Board of ECN and NRG have tried on many occasions to conclude a settlement agreement with the representatives of OMEN (former employees of ECN and NRG) on the termination of automatic indexation of the pensions. Unfortunately, these efforts have been unsuccessful, after which both management boards decided to make unilateral arrangements on behalf of the former employees who opposed the new regulation effective from 1 January 2007. OMEN has announced that it will submit an objection against the arrangement to the Court.

g) The Tax Authorities in Alkmaar informed ECN by letter that positions will be clarified, and it will further investigate if ECN qualifies as an 'entrepreneur' in the sense of the Turnover Tax Act. The tax administration proposed that from 2004, ECN itself would be held responsible for assessing whether the activities referred to in current discussions should be covered by the VAT system or not.

h) ECN has entered into a joint venture agreement with parties, DHI Water and Environment and VanderBilt University, on the subject of LeachXS, a software application that is being developed, with the intention of jointly marketing the application as a product. The parties agreed to take out adequate insurance as from the contract date, October 2006, for statutory liability arising from these activities up to at least € 3,000 per year and € 1,000 per event.

Bank guarantees provided

On the balance sheet date, ECN itself provided bank guarantees for an aggregate amount of € 1,344 to ABN AMRO.

Transactions with affiliated parties

The partners in the firm agreed that if the need arises, NRG will be granted one or more subordinated loans of no more than € 2,813 from ECN and € 1,532 from ECN Nucleair B.V. to reinforce its equity and the cash flow positions. It is expected that these loans will be called up in the future.

ECN and NRG perform work one for the other. These transactions are eliminated in the consolidated accounts and relate to services by ECN arising from a joint use of accommodation, infrastructure (networks and telephone), security, accounting services and other services. NRG on the other hand, performs services in the area of decontamination of buildings and similar services. Fees and fixed tariffs are agreed per year and documented.

In the financial year, the following transactions were effected between affiliated parties:

- For a total amount of € 6,120 between ECN and NRG for transactions primarily relating to the charging-on of the joint use of infrastructure (€ 5,800), services from the E&S unit after directly placed (€ 1,041), share in corporate staff services (€ 1,041), share in ma-

agement services (€ 943) and share in project facilities (€ 410).

- For a total amount of € 1,449 between ECN and WEF BV and Sunlab BV for transactions primarily relating to the costs of engaging managers for WEF and ECN.
- Transactions between ECN and Sunlab relating primarily to the charging-on of the costs of joint use of infrastructure. Costs are charged at the rates for the internal costs allocation applying at ECN.

At the end of the financial year, the following total of mutual receivables and debts remained:

- A total of € 9,157 between ECN and NRG
- A total of € 3,523 between ECN and WEF BV and Sunlab BV.

Notes to the consolidated statement of income

Operating income

Income

18 Financing from the State of the Netherlands

	2006	2005
- Basic, Engine and Knowledge funding	13,991	17,533
- Programme and Cooperative funding	30,589	19,389
Total	44,580	36,922

The financing from the Ministry of Economic Affairs comprises subsidies from the Ministry of Economic Affairs, the Ministry of Housing, the Ministry of Spatial Planning and the Environment. These subsidies are recognized in the financial year for which they were granted. The firm has to prove every year that the funds were spent lawfully. Based on the assessment of the respective ministries, part of the subsidies that have been granted may be deducted from future subsidies.

19 Third party income

	2006	2005
Third-party assignments	63,492	57,548
Increase/decrease work in progress	3,214	833
Provision for WIP	1,562	3,116
	4,776	3,949
Total	68,268	61,497

Third-party assignments include income from 100% third-party assignments, or a respective part of the income from assignments performed by third-parties. The latter part together with the part financed by ECN itself from the EZ funds comprises the total of the performed assignments under a partnership agreement. Third parties include the assignments commissioned by SenterNovem on behalf of EZ, assignments commissioned by the EU and other such assignments.

Specification of third-party assignments, including increase/decrease of work in progress, by client:

	2006	2005
Domestic trade and industry sector	23,410	23,099
Domestic energy sector	3,411	1,981
European Commission	18,799	10,941
Foreign trade and industry sector	12,122	12,858
Government agencies	2,761	2,720
Technological institutes	1,881	1,438
SenterNovem etc.	5,884	8,460
Total	68,268	61,497

20 Capitalised corporate production

Capitalised corporate production comprises operating expenses for work carried out by the company's own staff and with its own operating assets, credited or debited to investments or provisions.

	2006	2005
Movable assets	416	443
Immovable assets	189	473
Radioactive waste	1,031	962
Major maintenance and other provisions	189	310
	<u>1,825</u>	<u>2,188</u>

21 Other operating income

Other operating income is income from licenses (€ 603) and income from the lease with the Molybdeen facility. The latter item progresses parallel with the depreciation on the facility in accordance with ECN's accounting method. The difference between the charges to Tyco based on an annuities calculation (€ 146), and the depreciation determined according to the straight-line method (€ 19), is reported under financial fixed assets. The proceeds of WEF BV from income received from the lease of prototypes (€ 614) and the re-delivery of energy to the public grid of Eneco and Enerq (€ 5,136) are also reported under this item.

Operating expenses

22 Wages and salaries, social security and pension charges

	2006	2005
1. Permanent employment contract	38,896	38,676
2. Other personnel charges	<u>12,877</u> 51,773	<u>9,244</u> 47,920
3. Social security contributions	2,472	3,277
4. Pension charges	20,641	8,108
Total	<u>74,886</u>	<u>59,305</u>

Employees:	2006	2005
Average number of employees (FTEs):		
- Permanent employment contracts	738,4	756,4
- Temporary employment contracts (incl. promovendi)	86,6	60,8

Financial year total average	<u>825,0</u>	<u>817,2</u>
------------------------------	--------------	--------------

Note: Mentioned figures do not include temporary employees.

23 Depreciation tangible fixed assets

This item is specified as follows:	2006	2005
- Buildings, installations, fixtures and land facilities	2,573	3,522
- Instruments and other inventory	1,517	1,677
Total	<u>4,090</u>	<u>5,199</u>

24 Other operating expenses

This comprises:	2006	2005
- Projects	27,505	19,580
- Cost centers	13,457	12,336
- Staffing agency workers and seconded employees	2,773	1,933
- Addition and release provision doubtful debts	-123	-39
- Addition provision maintenance of buildings	700	3,224
- Addition provision for radioactive waste	766	260
- Release remaining provisions	-150	0
	<u>44,928</u>	<u>37,294</u>

25 Financial income and expenses

	2006	2005
- Interest and similar income	3,199	2,823
- Interest and similar expenses	-4,019	-3,204
Total	<u>-820</u>	<u>-381</u>

Interest income

	2006	2005
Interest compensation bonds	760	778
Interest compensation current account/giro	999	562
Result on the sale of bonds	42	415
Other interest income	1,398	1,068
	<u>3,199</u>	<u>2,823</u>

Interest expenses

	2006	2005
Interest compensation current account/giro	208	0
Addition of interest provision for redundancy costs	65	117
Addition of interest provision for radioactive waste	2,730	2,644
Addition of interest provision for Anniversary disbursement	34	0
Addition of interest provision for functional redundancy (FLO)	121	95
Addition transitional law retirement regulation	218	231
Impairment securities	596	0
Other interest expenses	47	117
	<u>4,019</u>	<u>3,204</u>

26 Taxes

The nominal tax rate was 29.6% in 2006 (2005: 31.5%). The effective tax rate is 7.5%. The difference between the nominal and effective tax burden arises from the exemption of corporate income tax applicable to Stichting ECN. The reported tax burden concerns the activities of ECN Wind Energy Facilities BV and Sunlab BV.

Statutory balance sheet of ECN as at 31 December (in € x 1000)

Assets			Liabilities		
	2006	2005		2006	2005
27 Fixed assets			28 Equity		
Tangible fixed assets	21,953	22,164	Foundation capital	45	45
Financial fixed assets:			Statutory reserves	779	875
· Participations in group companies	8,325	5,378	Other reserves	8,933	4,418
· Other participations	811	955	Undistributed result	-945	4,419
· Securities	25,283	25,536		8,812	9,757
· Other receivables	6,420	7,415			
	62,792	61,448	Provisions		
Current assets			Provision for early retirement (FUT)	0	0
Work in progress	9,320	8,297	Provision for redundancy	736	1,590
Receivables from group companies	2,242	1,673	Provision for radioactive waste	53,695	52,182
Receivables from other participations	444	635	Provision for transitional retirement regulation	0	4,400
Trade debtors	5,529	5,058	Provision for indexation of pensions	11,705	0
Inventory	267	232	Provision for compensation on retirement	2,306	0
Other receivables	4,049	2,747	Provision for FLO	1,098	825
	21,851	18,642	Provision for anniversary disbursement	715	681
Cash at bank and in hand			Provision for work in progress	579	607
Delta Lloyd Bank	0	7	Other provisions	3,738	3,871
ING/Postbank	50,528	34,745		74,572	64,156
	50,528	34,752	Current liabilities		
Total	135,171	114,842	Accounts payable	6,053	5,176
			Debts to group companies	2,759	494
			Debts to other participations	132	0
			Taxation	820	1,115
			Advanced funds from third parties	15,748	9,175
			Pension liabilities	5,119	7,661
			Other social security charges and personnel costs	4,664	4,740
			Other liabilities and accrued expenses	5,341	3,077
				40,636	31,438
			Debts to credit institutions		
			ABN/AMRO	11,151	9,491
			Total	135,171	114,842

ECN statutory statement of income 2006 (x € 1000)

	2006	2005
Operating income:		
Income		
· Funds from the State of the Netherlands	35,471	27,978
· Assignments and other funds	23,997	27,050
· Increase/decrease of work in progress	1,051	92
· Income at group companies	8,745	8,545
	33,793	35,687
	69,264	63,665
Capitalised statutory production	1,766	1,908
Other operating income	784	1,892
Total operating income	71,814	67,465
Operating expenses:		
Personnel costs: Wages	32,242	31,100
Social security contributions	1,592	2,337
Pension charges	17,257	5,381
Depreciation	3,325	4,564
Non-recurring impairment intangible fixed assets	810	0
Other operating expenses	20,840	20,812
Outsourcing to group companies	1,453	1,538
Total operating expenses	77,519	65,732
Operating income	-5,705	1,733
Financial income and expenses	-1,248	-689
Profit on ordinary operations before taxation	-6,953	1,044
Taxation on result from ordinary operations	0	0
Profit on ordinary operations after taxation	-6,953	1,044
Result from participations	6,008	3,375
Net result	-945	4,419

Notes to ECN's statutory financial statements:

The statutory financial statements were prepared in accordance with the provisions in Title 9, Book 2, of the Dutch Civil Code.

General principles for the preparation of the financial statements

For the general principles for the preparation of the financial statements, the principles for the valuation of assets and liabilities and determination of the result, as well as for the notes to the specific assets and liabilities and the results, reference is made to the notes to the consolidated financial statements, if not stated otherwise hereinafter.

27 Participations in group companies

Changes in participations are as follows:

	2006	2005
Balance as at 1 January	5,378	3,738
Debit: correction of equity due to	-5	-233
Credit: acquisitions	1,290	0
Credit: contribution from participations in consolidation	0	161
Credit: participations result	2,669	2,739
Credit : dividends / funds received	-1,007	-1,027
Balance as at 31 December	8,325	5,378

Minority interest in group result

ECN acquired the 30% interest of Kema Nucleair BV in the VOF NRG. At year end 2006, the third-party share in the group result is nil as against that third-party share in 2005 being € 446.

Rights and Obligations not apparent from the balance sheet

a) Stichting ECN, as a partner of the general partnership (NRG and WTW), is jointly and severally liable for the debts of this general partnership.

b) ECN and NRG perform work for each other. These transactions have been eliminated in the consolidated statements. It was agreed with NRG that, if necessary to shore up its equity and possibly improve the liquidity, it could call upon the extension of credit that will be provided in the form one or more subordinated loans by the partners up to a maximum amount of € 2,813.

Other information and signing of the financial statements

Remuneration for (former) directors and Supervisory Board members

In 2006, € 338 (2005: € 319) was debited to the Stichting and its group companies for the remuneration of directors of the Stichting. In 2006, € 65 (2004: € 49) was debited to the Stichting and its group companies for the remuneration of Supervisory Board members of the legal entity.

28 Equity

	Stichting Capital	Statutory reserves	Other reserves	Non-distributed profit	Total Equity
Balance as at 1 January 2005	45	0	2,875	2,418	5,338
Allocation of the 2004 result	0	0	2,418	-2,418	0
Result after taxation 2005	0	0	0	0	0
Breakdown of statutory reserve participations	0	875	-875	4,419	4,419
Balance as at 31 December 2005	45	875	4,418	4,419	9,757
Allocation of the 2005 result	0	0	4,419	-4,419	0
Breakdown of statutory reserve participations	0	-96	96	0	0
Result after taxation 2006	0	0	0	-945	-945
Balance as at 31 December 2006	45	779	8,933	-945	8,812

The statutory reserve concerns a reserve for 'retained profit at participations'.

Signing of the financial statements

Petten, the Netherlands 22 March 2007

Prof.drs. R.F.M. Lubbers
Chairman of the Supervisory Board ECN

Dr. A.B.M. Hoff
Chairman of the Board of Directors of ECN

Other information

Auditor's Report

In this regard, please see the auditor's report included below.

Provisions in the Articles of Association regarding the appropriation of the result

As generating a profit is not the primary aim of the Stichting Energieonderzoek Centrum Nederland, no provision was included in the Articles of Association regarding the appropriation of the result: The result in the financial year is therefore added to the other reserves of the Stichting.

Appropriation of the result for the financial year 2006

The 2006 financial statements were adopted by the Supervisory Board on 22 March 2007. The Supervisory Board determined the appropriation of the result in accordance with the proposal.

Proposal for the appropriation of the result for the 2006 financial year

The Board of Directors proposes to the Supervisory Board that the result for the financial year of +/- € 945 be charged to the other reserves.

Auditor's Report

To the Supervisory Board and the Board of managing directors of Stichting Energieonderzoek Centrum Nederland, having its registered office in Petten, The Netherlands.

Report on the financial statements

We have audited the accompanying financial statements 2006 of Stichting Energieonderzoek Centrum Nederland, Petten, the Netherlands, as set out on pages 70 to 83. These financial statements comprise the consolidated and company balance sheets as at 31 December 2006, the consolidated and company profit and loss account for the year then ended and the notes.

Management's responsibility

Management is responsible for the preparation and fair presentation of the financial statements and for the preparation of the management board report, both in accordance with Part 9 of Book 2 of the Netherlands Civil Code. This responsibility includes: designing, implementing and maintaining internal control relevant to the preparation and fair presentation of the financial statements that are free from material misstatement, whether due to fraud or error; selecting and applying appropriate accounting policies; and making accounting estimates that are reasonable in the circumstances.

Auditor's responsibility

Our responsibility is to express an opinion on the financial statements based on our audit. We conducted our audit in accordance with Dutch law. This law requires that we comply with ethical requirements and plan and perform the audit to obtain reasonable assurance whether the financial statements are free from material misstatement. An audit involves performing procedures to obtain audit evidence about the amounts and disclosures in the financial statements. The procedures selected depend on the auditor's judgment, including the assessment of the risks of material misstatement of the financial statements, whether due to fraud or error.

In making those risk assessments, the auditor considers internal control relevant to the entity's preparation and fair presentation of

Post balance sheet events

On 2 February 2007, the Appeal Court of Amsterdam judged the appeal from the judgment by the Court of Alkmaar of 25 March 2005, ordering ECN and NRG to pay a fine of € 25.000 on account of violation of environment regulations. The Court of Appeal ordered ECN and NRG to pay a fine of € 50.000, of which € 30.000 conditional, with a trial period of two years.

The former employees of ECN and NRG (OMEN) have announced through their attorney that they object to the unilateral amendment of the pension regulation as from 1 January 2007. No provision was taken for possible new legal proceedings announced by OMEN.

the financial statements in order to design audit procedures that are appropriate in the circumstances, but not for the purpose of expressing an opinion on the effectiveness of the entity's internal control. An audit also includes evaluating the appropriateness of accounting policies used and the reasonableness of accounting estimates made by management, as well as evaluating the overall presentation of the financial statements.

We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our audit opinion.

Opinion

In our opinion, the financial statements give a true and fair view of the financial position of Stichting Energieonderzoek Centrum Nederland as at 31 December 2006 and of its result for the year then ended in accordance with Part 9 of Book 2 of the Netherlands Civil Code.

Report on other legal and regulatory requirements

Pursuant to the legal requirement under 2:393 sub 5 part e of the Netherlands Civil Code, we report, to the extent of our competence, that the management board report is consistent with the financial statements as required by 2:391 sub 4 of the Netherlands Civil Code.

Amsterdam, the Netherlands, 22 March 2007

Deloitte Accountants B.V.

drs. P.J. Bommel RA CPA



ECN
Westerduinweg 3
P.O. Box 1
1755 ZG Petten, The Netherlands
Telephone +31 (0)224 564949
Fax +31 (0)224 564480
Email corp@ecn.nl

