Annual report 2013
IFE is an internationally oriented research institute for energy and nuclear technology. IFE’s mandate is to undertake research and development, on an ideal basis and for the benefit of society, within the energy and petroleum sector, and to carry out assignments in the field of nuclear technology for the nation. The Institute strives for a more climate-friendly energy system based on renewable and CO$_2$-free energy sources.

MAIN TASKS:

- Develop profitable, safe and environment-friendly technology within renewable energy, petroleum extraction and CO$_2$-management
- Maintain and further develop national expertise within reactor safety, radiation protection and nuclear technology based on the Halden- og JEEP II-reactors
- Utilise the Institute’s unique nuclear reactor safety expertise in other spheres of society
- Conduct basic research in physics based on the JEEP II-reactor at Kjeller
2013 was a particularly challenging financial year for IFE. The financial result was greatly affected by the loss of contracts from the nuclear power industry and safety research and by continued repercussions from the Fukushima accident in 2011. IFE’s reputation was affected by the Ministry of Foreign Affairs’ review of the Institute for violation of Norwegian export legislation. The “A new IFE” project was created in order to secure and strengthen further operations and to give IFE’s researchers the frameworks they need in order to promote creativity. The most urgent measure was to lay a foundation to reverse the negative cash flow and reduce fixed operating expenses. The frameworks relating to the Halden Project were evaluated, and the economic base was strengthened. New emphasis was placed on streamlining and synergies between operations at Halden and Kjeller and between the various specialist sectors. A decision was made to reduce the number of employees in administration and specialist sectors by around thirty FTEs. This process has now begun and is expected to be completed in 2014. Procedures for export licence applications were centralised and reinforced.

IFE’s research results are characterised by quality and a long-term strategy. As a result of this emphasis on long-term considerations, the Institute is capable of becoming an international spearhead figure in selected specialist fields. Thus the nuclear technology initiative has formed a basis for IFE’s incredible success in the fields of petroleum and pharmaceuticals. The Institute’s early focus on materials technology is now showing fascinating, exciting results in the field of renewable energy technology. However, long-term initiatives are also financially demanding at times, and this is why the Institute has to have an economic base which permits such investments. IFE’s Articles of Association describe the fact that the Institute’s objective is to work on a non-profit basis beneficial to society in order to conduct research and development in the field of energy and in other fields where the skills of the foundation are particularly appropriate. Thus IFE has stated in its Articles of Association that its objective is to earn money so as to be able to conduct research, and not to conduct research for the purposes of earning money. Acquisition is not the objective of IFE. Working on this basis, the Institute offers contracts and services to trade and industry both in Norway and internationally, thereby constituting an important organisation and making Norway an attractive knowledge society.

Norwegian politicians have a unique weapon in their armoury by reinforcing the technological industrial institute sector, in this way placing Norway on the international technological knowledge map and building international relations in fields such as renewable energy technology.

Managing Director
Eva S. Dugstad
Priority areas

- Operation of the JEEP II reactor
- Materials science based on neutrons from the JEEP II reactor
- Participation in designing and establishing the European Spallation Source (ESS), and adaptation to the instrumentation relating to JEEP II for this
- Extension of capacity and expertise in the field of electron beam welding
- Assignment projects in the fields of environment and radiation protection

JEEP II is a heavy water-moderated reactor with a thermal output of 2 MW. The neutron flux is $2 \times 10^{13} \text{n/cm}^2 \text{sec.}$ The plant requires a licence, with regulated requirements with regard to safety, documentation and reporting to the authorities.

In 2013, IFE’s Reactor Operation department hosted the Nordic Meeting on Reactor Physics, which took place on 18 and 19 April at Kjeller. This conference attracted researchers and other representatives from the Nordic reactor environment and discussed topics such as Monte Carlo modelling, gamma tomography, neutron hydraulics and thermal hydraulics. For more information, see [www.ife.no/en/departments/reactor-operation/rpnc-2013/](http://www.ife.no/en/departments/reactor-operation/rpnc-2013/).

JEEP II currently forms a basis for an extensive cooperation with almost 40 national and international research institutes in the field of basic neutron-based materials science research. A number of critical material properties can only be investigated with the help of neutron beams, and these measurements can provide important information besides the data that can be gleaned using X-ray and electron beams.

The cooperation between IFE and ESS (European Spallation Source), the world’s most powerful neutron source which will be built in Lund in Sweden, is a vital part of the activities taking place at the sector’s Physics department. The researchers at the Physics department play an active part in ESS committees as a member of the Scientific Advisory Committee, the Norwegian member of the ESS in-kind review committee (vice chair) and the national coordinator for ESS activities.

IFE’s unique expertise in the field of electron beam welding (EB) has placed the Institute in an important position in respect of the oil supplier industry and others. An increase in demand for this type of assignment has made it necessary to extend EB capacity at IFE. The Electron Beam Welding and Mechanical Workshop department (EBMW) purchased a used EB machine in early 2013. This has been assembled and installed over the course of the year, and it can weld components of a size which was previously impossible at IFE. The assembly and installation work was largely carried out by IFE’s own staff.

The sector also carries on significant activities in the field of irradiation technology, where irradiation of Si crystals for use in the electronics industry (NTD Silicon) has dominated over the past 10 to 15 years. Silicon irradiation, as well as the production of radioisotopes and sources, is a purely commercial activity and a necessary supplement in order to have sufficient assets to be able to run the JEEP II research reactor.

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The primary aim of the Sector for Energy and Environmental Technology is to create a cleaner, more eco-friendly society by developing new technology for renewable energy production, efficient energy consumption and cost-effective CO\textsubscript{2} handling. Our priority areas are in the fields of silicon-based solar cell technology, floating wind turbines at sea, development of new materials for batteries, mineral processing with eco-friendly processes, energy system analysis and CO\textsubscript{2} capture and storage.

The sector currently has an extensive experimental infrastructure, with advanced laboratories within the fields of silicon production, silicon-based solar cells, hydrogen and CO\textsubscript{2} capture. In particular, we are seeing increasing interest in silicon for use as an anode material in Li-ion batteries and new CO\textsubscript{2} absorbents for CO\textsubscript{2} capture. In 2013, the sector completed a pilot for production of hydrogen from biogas at the new R&D laboratory at Akershus EnergiPark in cooperation with Prototec and ZEGPower. IFE has in cooperation with Dynatec Engineering verified with very good results, a completely new type of silicon reactor based on a centrifuge principle. A new two-year project will be starting in 2014 in order to bring this reactor technology closer to commercialisation.

The activity within renewable energy and environmental technology has increased in 2013, and a number of new projects have been launched with partners both here in Norway and abroad. There have been both direct, bilateral projects with customers and cooperation projects supported by EU framework programme and thematic programmes at the Research Council of Norway. The sector currently has almost 100 external cooperation projects running. Below are some examples.

In the field of energy system analysis, the sector has started an exciting new long-term cooperation with the municipality of Oslo in 2013 in the field of development and implementation of a new energy strategy. We have begun to create an energy model for Oslo as part of this cooperation. The primary objective is to find optimum solutions so that Oslo can meet its ambitious targets to reduce its greenhouse gas emissions by 50% compared with 1991 levels before 2030, and to be greenhouse gas-neutral by 2050.

IFE was the Norwegian project manager for the Nordic project “Nordic Energy Technology Perspectives” which came to an end in 2013. This was a cooperation project involving Nordic research environments, Nordic Energy Research and the international energy agency in Paris. This work involved creating detailed analyses of the Nordic energy system and analyses of various scenarios with regard to how the Nordic countries can reduce emissions of greenhouse gases. The results also indicate how important a role the Nordic energy system can play in the decarbonisation of Europe.

In the field of CO\textsubscript{2} capture, the sector is taking part in a cooperation project relating to development of a process which has the potential to significantly reduce energy consumption. Partners are Alstom, Tel-Tek, Telemark University College, the Swiss Federal Institute of Technology and Alstom Power in Germany. IFE’s role in the project is to try out and evaluate natural absorbents as well as advanced synthetic materials.

In respect of our wind energy initiative looking at floating wind turbines, we launched a research council project in cooperation with the Norwegian University of Science and Technology, the Technical University of Denmark, Statoil and Statkraft to look at design sea loads for offshore wind turbines in shallow and medium depth waters. Waves and currents affect wind turbines at sea. These forces can govern how the turbines are to be designed and how much they cost to build. Storms with large waves cause extreme loads which the turbines have to withstand. Waves which strike the turbine year upon year may cause fatigue and harmful cracking which must be avoided. It is necessary to understand natural phenomena in order to calculate these sea loads on the turbine. You first have to understand how the water in the sea moves. Then you have to understand what forces are exerted on the wind turbine as a result of these water movements. With this knowledge, you can then design offshore wind turbines which withstand everything they need to withstand, while not overdimensioning them and making them unnecessarily costly.

IFE has worked in cooperation with Nordic Mining to complete a promising new method for the production of alumina, a raw material for the production of aluminium. This process is based on a mineral known as anorthosite, of which there are natural deposits in Norway. Gudvangen is in the order of 500 million tonnes.
IFE Petroleum Technology supplies services and products between basic research and advisory services within a selection of fields of application. Many of the operations are based on combining advanced experimental activities, analysis, numerical simulations and theoretical models.

The field-based testing and analysis services associated with tracer operations were separated out into the company Restrack AS in the autumn of 2013. 12 employees left IFE in order to further develop and sell these services via the company, of which IFE is a majority owner. The remaining department, Tracer Technology, is continuing with further development of its tracer-based R&D activities. The department immediately consolidated its position by being awarded the new SFI for IOR (Improved Oil Recovery), together with its partners IRIS and the University of Stavanger. These three partners complement one another beautifully, and there are major expectations of professional and market-related success as a result of this partnership. Tracers in an IOR context have significant potential, not least in the context of flow and calculation expertise at IFE.

SPT Group (with its OLGA software), partner for multi-phase activities for many years, has been sold to Schlumberger. Prior to the sale, the code was arranged so that independent plug-ins can be developed so that special functionality can be integrated into OLGA without interfering with the OLGA code. Thanks to its in-depth knowledge of this code and general multi-phase expertise, IFE is in an excellent position to supply such modules to OLGA, irrespective of the further development of the OLGA code itself. The first such projects are in progress and IFE wishes to develop this market further.

The multi-phase activity, together with SINTEF, was also awarded funding in order to build new infrastructure. IFE has itself funded extension of the well loop building, and the infrastructure funding will place us in a position whereby we can utilise our expertise in the new focus areas of detectors, measurement and instrumentation.

The materials and corrosion activities have continued their extensive industrial cooperation, with good financial and professional results. We have built and renewed important equipment throughout the year thanks to ongoing projects. The most important example of this is the CO₂ corrosion loop, which was opened in autumn 2013. This is financed

by industrial partners and by Climit funding from the Research Council of Norway, and significant progress is expected of this activity in years to come. The enterprise has also enjoyed success with deliveries on fixed price projects.

The computationally oriented materials operation was separated out into a separate department as of New Year 2013 and has delivered good results. The most important customers are primarily found in the process industry, but a portfolio of customers in the petroleum sector is also being built up. Here, various analyses associated with extension of the service life time of installations and equipment will be an interesting market field. IFE has a considerable portfolio of software which has been used successfully in a number of applications. It is an important part of the strategy of further developing this in order to create new business opportunities. We sold nine more licences for the welding modelling tool Weldsim in 2013, and this may provide a foundation for many new projects in future.

IFE Petroleum Technology works with patenting and IPR management. Two patents appear to be particularly important in 2013. One has already been sold to a partner and will be developed in connection with this party. We are planning to develop the other patent ourselves before we involve external parties.
The Isotope Laboratories have dedicated laboratories for production, packaging and quality control of radiopharmaceuticals. These laboratories are classified in respect of cleanliness classes in accordance with international GMP (Good Manufacturing Practice) rules and in accordance with radiation protection legislation.

The Isotope Laboratories have been working for a number of years of extending and building up premises and equipment for the contract manufacturing of Xofigo, a radiopharmaceutical which is based on the radioisotope Ra-223 and is used to treat prostate cancer patients with bone metastasis. This product was approved in the USA in May 2013 and in Europe in November 2013. The Isotope Laboratories have been routinely manufacturing Xofigo since May. The facilities were officially opened by Trond Giske, Minister of Trade and Industry, on 20 June. Both the Norwegian Medicines Agency, American pharmaceutical authorities, FDA, and the authorities in Brazil have inspected the Isotope Laboratories in 2013 in connection with this production.

This project has also helped the Isotope Laboratories to create a lot of new jobs. Staff numbers have more than doubled in the last couple of years.

In addition the Isotope Laboratories are working with other development projects in the field of radiopharmaceuticals. The focus is to be able to offer small start-up companies manufacturing services where the requirements for the manufacturing of pharmaceuticals are met, and which also meet radiation protection requirements.

The sector has significant skills in the field of analysis of radioactive substances. These are used in both contract analyses and development of new products.

The Isotope Laboratories have continued to play their important part as a distributor of radiopharmaceuticals to the Norwegian market in 2013. The sector operates as a central “isotope pharmacy” for Norway and controls and distributes all radiopharmaceuticals directly to the nuclear medicine departments at Norwegian hospitals. The import and distribution of short-lived products which are not yet produced at Norwegian PET centres is another of its important tasks. The sector’s skills in the distribution of hazardous goods and radiopharmaceuticals are also applied in connection with clinical trials for our partners. In 2013, the Isotope Laboratories have distributed radiopharmaceuticals to individual patients throughout the world.

The Isotope Laboratories also perform a range of administrative tasks. These tasks include maintaining statistics relating to the consumption of radioactive substances for the Norwegian Radiation Protection Authority, advising Norwegian hospital wards in the use of radiopharmaceuticals, teaching and building up hot labs. The sector also has a member in one of the expert groups linked with the European Pharmacopoeia, which is a reference book which sets quality standards for pharmaceuticals.

The strong growth within the department – particularly in 2013, when it went from 43 staff members to 77 – led to IFE choosing to establish the activity as an individual sector. The Isotope Laboratories underwent reorganisation on 1 December 2013, switching from being a department in the Nuclear Technology and Physics (NTF) sector to becoming a separate sector with six specialist departments. This has reinforced its pharmaceutical activities and the management of the same, and placed the enterprise in a better position from which it can continue its growth.
Background
Director-General Luis Echávarri of the OECD’s Nuclear Energy Agency (NEA) has often stated that the Halden Project (HRP) is one of the OECD’s most successful cooperations in respect of research. It has become a model for all new research projects under the auspices of the NEA and has always had the full support of OECD NEA.

2013 has been a hectic year both administratively and professionally. On the administrative side, the emphasis has been on continuation of the Project. In the autumn of 2012, a report was compiled on behalf of the international board (HBM) entitled “Views on the Long Term Direction of the Halden Project 2015-2024”. This report was approved at the beginning of 2013, and in the winter of 2013 it was used as a basis for preparation of HRP’s framework programme for its research activities in 2015-2017. This framework programme was approved by HBM in June 2013, and in the autumn of 2013 the programme was presented to all current participants in HRP, as well as a couple of candidate countries.

Discussions with the foreign members on a new international research programme for the period 2015-2017 have now progressed so far that the foundation for sufficient foreign support can be considered to be in place. At the HBM board meeting held in Paris on 6 December 2013, all participants expressed their intention to continue with their membership of the Halden Project in a new contract period. The United Arab Emirates became member country number 20 from mid-2013. The Emirates are otherwise in the process of building four major nuclear power plants (1400 MWe each) which will be completed in 2017-2019 from mid-2013. The Emirates are also the process of building four major nuclear power plants (1400 MWe each) which will be completed in 2017-2020.

On the professional side, we have followed a traditional process with a total of 40 reports presented at HRP’s international conference at Storefjell in March 2013, which was attended by around 300 participants. 30 papers were presented at international conferences in 2013. HRP has also arranged five international workshops in 2013, and a one-week summer school on the theme of “Principles of fuel behaviour modelling and practical applications”.

Research programmes in 2013
The utilisation level of reactor fuel has gradually increased over time in most countries using nuclear power. This reduces the amount of radioactive waste and radiation exposure for the surrounding area by means of handling and processing after use. However, this requires extensive documentation and experimental verification in advance so as to demonstrate that safety requirements are being met – even with increasing utilisation. The experiments in the Halden reactor are providing a significant data base for the safety approval of fuel. The well developed instrumentation technology is being used to measure phenomena relevant to safety, such as pressure increase in the fuel in the event of power changes, stability during long-term irradiation, and thermal and mechanical properties. This makes it possible to study both individual parameters and the general reliability of fuel rods.

Full or partial loss of the cooling water and the consequences for the fuel in the reactor core is a significant theme in international research. The Halden reactor has unique special equipment, allowing us to study the behaviour of the fuel under such conditions. This makes it possible to examine the relevance and validity of current safety criteria in the event of serious accidents (loss-of-coolant accident, LOCA) for pressurised and boiling water reactors as well as Russian VVER reactors. The results from this series of experiments have attracted significant international attention. They are being actively used internationally for validation and comparison of safety codes and to adapt safety requirements for increased fuel utilisation.

Safety organisations and industry in leading nuclear nations are now devoting a growing proportion of their research and development to problems linked with the ageing of their plants. Central to this work is the requirement for verification of the fact that the properties of materials and structures will not change to an extent which will impair basic safety requirements and margins when the operating time increases. If special measures are needed to increase the operating time, it is important to be able to establish that such measures have the desired positive effects.

Corrosion of the fuel cladding limits the useful life and constitutes a safety risk. Thermal-hydraulic conditions, temperature and cooling water chemistry are all important factors in this context. Current cladding materials and new alloys are being examined in the Halden reactor. The experimental systems provide very good opportunities for simulating relevant operating conditions in current and future plants.

The Halden Project’s research programme is the cornerstone for MTO operations at IFE in Halden. New basic knowledge, methods and technology are being established here which can be used to prevent accidents happening, and to limit any consequences. In addition to the Halden Project, the sector is carrying out commissioned research for the member countries in the form of specific experiments at IFE’s laboratories, field studies and installation of operation monitoring systems at nuclear power plants. The MTO sector is also running assignments and providing consultancy services for industry and supervisory authorities in Norway. The primary market is petroleum, but the transport sector and traditional process industry are also customers as well as the electricity sector.

Alarm systems have rarely been liked by users, partly due to a lack of user-friendliness. HRP has devised what is known as a status-based alarm system, demonstrated it and examined its user-friendliness together with operators. The results shows that secondary alarms during an incident were discovered more quickly and more frequently with an alarm system of this type. The user-friendliness was valued highly by participants.
The primary objective of NUSP is to obtain key information for use in safety assessments of fuel and materials to be used at nuclear power plants. Its work involves the design, production and implementation of experiments using advanced test rigs in the Halden reactor. The measurement results are transferred online from the reactor core via a data collection system to the database, and from there to our customers. Around 60% of the business in the sector involves commercial contract research for international organisations, while the remaining 40% is research for the OECD Halden project.

The Halden reactor is the main tool for fuel and material surveys. The reactor was operational for 193 days in 2013. This gives an accessibility factor of 53%, which is good for a research reactor. A number of experiments are taking place under standard Halden reactor conditions. When using experimental circuits installed in the reactor, it is also possible to carry out experiments under conditions which are representative for commercial power reactors or simulate more demanding or unwanted incidents. NUSP has developed an advanced set of sensors which make it possible to acquire detailed information on how the properties of fuel and materials change when they are irradiated and in various operating states. The results are mainly used to develop and validate safety analysis models in connection with the extended utilization of existing products and licensing of new, improved products.

Fuel rods in nuclear power plants are made up of a long column of uranium dioxide pellets in a metal tube (cladding) which is filled and pressurised with helium and welded together. The heat generated in the fuel rods during operation is transferred to water at high pressure (the reactor coolant) that flows over the surface of the fuel rods. In the event of a loss-of-coolant accident (LOCA), the fuel rods lose both cooling and external over-pressure. The observations made by NUSP over a number of years of LOCA testing have shown that during a LOCA the temperature of the cladding increases significantly over the course of a few minutes. With this increase in temperature and the lack of external over-pressure, the fuel rod cladding soon balloons and eventually bursts, while the fuel pellets become fragmented. In the case of extremely high irradiation time (or "burn-up"), emissions from fuel rods which fail during a LOCA may consist of fuel particles if they are small enough, as well as radioactive gases.

To examine the cause and nature of fuel fragmentation during a LOCA, NUSP carried out two successful tests in the Halden reactor in 2013 using two identical fuel rods under different conditions. One test was run until the cladding ballooned and burst, while the other was stopped after ballooning and just before burst. The results indicate that the fuel fragmentation takes place early on in the course of the accident scenario and not at the end when the cladding bursts and the internal gas pressure is released. This information will be used by safety authorities to help them better understand how fuel rods behave during a LOCA, and hence be able to improve their transient fuel performance models.

Around 20 to 25 different experiments are normally running in the Halden reactor at any one time. Some are long-term experiments where various ageing mechanisms are being studied. The aim is to acquire a better knowledge of how radiation affects the reactor’s component materials with a long irradiation time. A study of this kind in 2013 examined the crack growth rate under conditions corresponding to those inside boiling water reactors. The parameters included in the survey were material type, radiation dose, electrochemical corrosion potential, temperature, stress intensity and heat treatment after irradiation. The crack growth rate in samples which were heat-treated appears to be lower than in the samples which had not been treated in this way. This is a positive finding for measures to prevent plant ageing.
The work of **Safety - MTO** aims to ensure safe and efficient operation of complex processing plants such as nuclear power plants, petroleum installations, and other energy and processing plants, as well as transport systems. The term “Safety - MTO” is based on the fact that improvements are made to safety by considering humans, technology and the organisation as a total system, utilising an interdisciplinary approach.

Experience from accidents shows that they are often caused by combinations of human errors, failure of technical systems, and/or organisational conditions. Understanding this interaction forms a basis for optimal utilisation of the technology, and building robust organisations where decisions are made on the best possible foundation.

**Human reliability:** The nuclear power industry is constantly working to improve safety. The technical systems for controlling nuclear power plants are gradually becoming more reliable, and this means that the human contribution to safety and reliability is now given more focus. Increasingly, methods for analysing human reliability (HRA - Human Reliability Analysis) are being applied. MTO has carried out a major international project in which various HRA methods are being evaluated against empirical data from human-machine studies in HAMMLAB. The final report was issued in 2013 and documents strengths, weaknesses and potential for improvement of the various HRA methods. This report will provide a point of reference for the nuclear power industry in its constant efforts to improve human reliability, particularly in demanding accident scenarios. The knowledge of HRA is now also being transferred to the petroleum industry, where MTO has established a Petromaks project with Statoil, DNV GL, SINTEF and the Norwegian University of Science and Technology. The purpose is to adapt HRA methods for use in accident scenarios in the petroleum industry, in order to handle risks during the design and operation of petroleum installations.

**Integrated System validation:** When designing new and modernising existing control rooms, the nuclear power authorities require safety to be documented by means of an independent Integrated System validation (ISV). This is one of the top priority research tasks within the Halden Project. A set of human performance criteria has been developed which is being tested experimentally and used as a basis for preparation of international standards. Knowledge on ISV methods and skills are being shared through MTO’s participation in the work group for human and organisational factors (WGHOF) within the NEA (Nuclear Energy Agency). Furthermore, in 2013 we have carried out ISV projects for nuclear power plants in Finland, Sweden and the USA.

**Control room systems and operator interfaces:** HAMMLAB is used for the design and early testing of various operator support systems and user interfaces. A new, status-based alarm system indicated through operator tests that disruptions in the system were discovered significantly earlier than with a traditional alarm system. Based on design experience from HAMMLAB and the oil industry, a new large screen was developed and installed at the Halden reactor. Feedback from Halden reactor operators has been very good. In cooperation with INL (Idaho National Labs, USA), IFE works with providing knowledge on control room upgrades for American nuclear power plants. IFE has supplied prototypes of operator interfaces and large screen displays to INL’s simulators, and these are being used by American power companies as a basis for design and requirement specifications. Large screen displays are still being developed for offshore petroleum installations, and in 2013 a number of projects were carried out for Statoil (Visund, Valenom, Sleipner, Kristin). IFE has been facilitating alarm analyses for Draugen and Ormen Lange throughout 2013 via a framework agreement with Norske Shell.

**Integrated Operations:** The Centre for research-based innovation on integrated operations (IO centre) is now providing results which the petroleum industry can make use of. A number of case studies have been carried out such as a) cooperation and management during meetings for planning and production optimisation, b) risk management in maintenance and modification planning, and c) improvements of Telemedicine capabilities. Tools, methods and prototypes have also been developed, such as IO-MAP, supporting distributed teams in maintaining safety during the planning of maintenance and modification work, SOFIO, a method for training on IO cooperation, and “Scenario Composer”, a prototype for efficient planning of offshore maintenance, taking into account critical resources such as helicopter seats and beds at the installation. The prototypes are being tested in realistic environments at various oil companies, and associated projects to the IO centre have been carried out for Eni, GDF SUEZ, BP and Statoil in 2013.

**Assistance projects for the Norwegian Ministry of Foreign Affairs:** VR (Virtual Reality) technology has proven to be a very useful tool for design, maintenance and training. Radiation visualisation is one important application, and a series of dedicated tools are being developed to assist with VR-based training and education. Such tools can be used to plan the decommissioning of nuclear plants and reduction of radiation doses when working in radioactive areas. The DRIVE project is a part of the cooperation between the Norwegian and Russian supervisory authorities and aims to improve monitoring, planning of tasks and personnel training in Andreyeva Bay by introducing better visualisation of existing and future radiation data. VR is used for tasks such as optimisation of waste disposal, increasing understanding of radiation among workers and hence improving safety for both staff and the plant.
## Income Statement 2013

(Amount in NOK 1 000 )

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The Institute has had a strained financial situation in 2013, mainly due to a lack of project inflow with regard to nuclear activities at the Halden reactor. The Board is taking this situation very seriously, as despite cost reduction measures and increased sales efforts in 2013, this enterprise still has to budget with a large operating loss in 2014. IFE’s pension obligations have increased considerably over time. As at 31.12.2013, a calculation pursuant to NRS6 has been presented for the first time with sufficient certainty to allow the liability to be recognised in the accounts. The Board is not satisfied with the financial results for 2013. The Board is supporting administration’s efforts with “A new IFE”, where the aim is to implement structural changes in order to introduce a more businesslike organisational culture and increase the profitability of the enterprise so that the foundation can operate with an operating margin of at least 5% under normal conditions. The Board is of the opinion that it is crucial for the administration to put in place specific measures to resolve the financial problems relating to activities at Halden as the first stage of this work.

The Board wishes to highlight the very good financial results at the Isotope laboratories, which were established as a separate sector in December 2013. Many years of work were completed with the official opening of the production plant for the radioactive medication Xofigo in June 2013. The Board wishes to praise the sector for having dealt with strong expansion with significant growth in numbers of employees while also working flat out on their regular operating and research tasks. However, the Board notes that this has had a major impact on the work environment.

IFE’s petroleum sector has built up significant professional recognition both nationally and internationally over the past 25 years. The Institute has extended its activities within the fields of both multiphase technology and corrosion and built unique new experimental systems in 2013. IFE’s technology has awakened new interest in connection with greater emphasis on CO₂ handling and the transport of CO₂ in pipelines. The Institute established a new subsidiary, Restrack, as a spinoff from IFE’s tracer enterprise in 2013. The Board is pleased to announce that both Restrack and the tracer enterprise which has returned to IFE are able to demonstrate good results both professionally and financially. IFE’s tracer enterprise has become a partner in the new centre for enhanced oil extraction (IOR-SFI) which was established in Stavanger in 2013.

The Institute is maintaining its international position in the field of neutron-based characterisation of materials for hydrogen storage. The JEEP II reactor is a prerequisite for this enterprise. Also in 2013, IFE has spearheaded the EU’s research programmes in this field. An exciting new research project which was launched in 2013 involved the irradiation of concrete for the nuclear power industry at the JEEP II reactor. The project is being executed as a cooperation project between the Nuclear Technology and Physics and Nuclear Safety and Reliability sectors on behalf of Japanese and Finnish nuclear power plants. Its purpose is to study how concrete behaves when it is exposed to neutrons, and hence to predict the ageing process of concrete in nuclear reactors. The JEEP II reactor is particularly well suited to studies of this type, and the project has been very successful to date and will continue in 2014. However, the Board is concerned about the declining income from irradiation for the JEEP II reactor in 2013.

The Board has noted the positive development in the Energy and Environmental Technology sector, which has delivered robust financial results in 2013. The municipality of Oslo selected this sector as a strategic partner for preparation of a new energy strategy. This indicates that its activities are relevant and gaining professional recognition externally. The Board is also very pleased to see that the Centre for Environment-friendly Energy Research (FME) has been refinanced in 2013 with regard to solar energy. However, the Board is concerned about the negative financial results of IFE’s solar activities. The Board is pleased to see that 3D Float software, which IFE has developed for the design of offshore windmills, has now been adopted by commercial projects for the first time. It is also pleasing to see that the deliberate focus on the EU has led to IFE becoming a partner to two new EU projects in the fields of solar cell development and CO₂ capture.

The scope of the MTO sector’s activities in the petroleum sector is increasing. Integrated operations are an important specialist field for MTO, and the IO-CENTER (Center for Integrated Operations in the Petroleum Industry) has been an important prerequisite for MTO’s partnerships with ENI concerning organisational development for Goliat, and with GDF SUEZ concerning collaborative areas for planning in 2013. The MTO sector has also been awarded a contract with British Petroleum with regard to work processes on the UK continental shelf. This is MTO’s first contract with the oil and gas industry outside the Norwegian continental shelf. As regards the nuclear power industry, MTO bears overall responsibility for integrated system validation of the modernised control rooms at the Loviisa power plant in Finland. Integrated system validation is a vital research topic, and a number of bilateral projects for Swedish, Finnish and American power plants are expected to materialise from this research over the next few years.

The Nuclear Safety and Reliability sector (NUSP) experienced a very strained financial situation in 2013. At the same time, the enterprise underwent an investigation as it was suspected of violating the Export Control Act. In 2013, the Board has approved measures to reduce costs for the sector, such as downsizing, and the Board notes that the administration is working to enhance marketing and profitability in projects. In 2014, the Government will discuss IFE’s licence application to continue running the Halden reactor. Thus the Board is of the opinion that reinforcement of project budgets is absolutely crucial to the running of the Halden reactor and the activities in the NUSP sector. A continued deficit within NUSP will deplete IFE’s other operations. In 2013, the project management has visited the member countries involved in the Halden project in order to gain support for a new three-year period (2015-2017). The Board notes that participants are giving off positive signals in respect of a new period, but realises that it may at the same time be difficult to implement an increase in the membership fees. For ongoing operation of the Halden reactor, it is crucial to ensure that a market exists with sufficient willingness to pay for the NUSP sector’s services. The Board has launched an initiative in order to analyse the market. The Board has also initiated efforts to allow financial and safety-related aspects to be dealt with if it is not possible to continue with the Halden Project.

The Board is pleased that the State has indicated shared financial responsibility for future decommissioning of IFE’s nuclear plants. It is now important to put in place a final arrangement with regard to how decommissioning and financing are to be organised, and to ensure that IFE’s good communication with
the authorities continues in order to fine good solutions to the issues regarding the handling of highly active waste and future storage/disposal of the historic nuclear fuel in Norway.

Subsidiary IFE Venture AS, which has built up a significant portfolio of companies, is continuing to commercialise its research operations at IFE in accordance with the Institute’s commercialisation strategy. Commercialisation of IFE’s tracer technology was completed this year via Restrack AS. The Board notes that there has been a good increase in the value of shares in 2013, too. The Institute sets great store by protecting the organisation’s intellectual property rights, and in 2013 applications were submitted for 18 (7) patents. IFE was granted 3 (3) patents. The figures in brackets relate to 2012.

The Board notes with satisfaction that the production of scientific articles and lectures is up on 2012. In 2013, 94 (91) articles were published in international journals with peer review systems, 49 (49) lectures with proceedings were held, and 203 (221) reports were issues to various clients. The Board considers it important for the Institute to maintain its ambitions in respect of publication, and is increasing the publication of scientific articles and reports.

Health, safety, environment

HSE statistics at IFE can also demonstrate good results in 2013. Routine emissions of radioactivity to air and water in 2013, as in previous years, have been very small and well below the limits set by the Norwegian Radiation Protection Authority. The individual doses of radiation to the Institute’s employees have also been well below the limits set by the authorities.

IFE has a good work environment, with low levels of sick leave. The work environment at IFE is followed up by means of regular HSE surveys and reports. The Board sets great store by the fact that IFE is an IW (Inclusive Workplace) company. Sick leave in 2013 was at 3.7%, which is 0.4 percentage points lower than in 2012 (4.1%). Four injuries were recorded in 2013. No serious accidents or incidents were reported in 2013. The Board considers this to mean that the Institute is meeting its HSE targets.

The Institute’s nuclear plant has been run in accordance with licensing requirements and other authority requirements in 2013. The Board notes that the nuclear plants and IFE’s other laboratories maintain good standards in terms of safety.

The Board notes that the Norwegian Radiation Protection Authority indicated non-conformances in IFE’s safety culture in an audit report in April 2014. The Board is taking this matter very seriously and is expecting the non-conformances to be eliminated by the deadline.

Finance

The consolidated annual accounts include, besides the IFE foundation, the wholly owned subsidiaries IFEs Boligselskap AS and IFE Venture AS and subsidiaries of IFE Venture AS. The Group’s total revenue in 2013 amounted to NOK 810.2 million (NOK 801.3 million) with a deficit of NOK -43.2 million (NOK 34.5 million) after tax. The figures in brackets relate to 2012.

The IFE foundation in 2013 had revenues of NOK 807.6 million (NOK 785.5 million). The net profit for the foundation for the year amounted to NOK -41.1 million (NOK 11.6 million). Equity classification and allocation of the profit for the year have been carried out in accordance with generally accepted accounting standards.

The profit for the year and financial position are characterised by three factors; writedown of uranium and heavy water, future pension obligations in accordance with the NRS6 standard and the negative financial result for the NUSP sector.

Writedown of stocks of uranium and heavy water in the amount of NOK 35 million are charged to the operating profit for 2013. This was regarded as necessary due to the uncertainty linked with both calculated sales value and the market value of uranium and heavy water.

As at 31.12.2012, IFE has a shortfall of NOK 73 million in the pension scheme (the Norwegian Public Service Pension Fund, SPK) which is offset directly against IFE’s equity as at 31.12.2013. In addition, an estimate has been presented for the first time of total liabilities with regard to the Norwegian Public Service Pension Fund in line with Norwegian accounting standards (NRS6), which takes into account adjusted life expectancy and future salary adjustments, among other things. The implementation effect of this estimated future pension liability is extremely uncertain, but it has now been offset directly against equity in the amount of NOK 238.6 million (see note 10). This was done on 31.12.2013 in accordance with generally accepted accounting standards.

Financial risk

The Board deems liquidity within the company to be very tight. Total cash flow from operations within the IFE foundation amounted to NOK 35.6 million, while profit before tax amounted to NOK -41.1 million. This difference is due mainly to the writedown of uranium and heavy water of NOK 35 million, but also to an increase in advances from customers of NOK 21.2 million. Total investments amounted to NOK 19.6 million, compared with NOK 27.4 million in 2012. The investment need in 2014 amounts to around NOK 30 million, which is mainly expected to be financed from operations. Liquidity is expected to improve in 2014, which is reflected in both actual cash and cash equivalents in the first quarter 2014 and in the liquidity forecast for the rest of the year.

The interest rate and currency risk and the risk of bad debt are deemed to be as moderate. The foundation has long-term loans of NOK 51.4 million where floating interest rates are applied, and in the current stable interest market this is not considered a significant risk. Changes in currency exchange rates involve a financial risk for the foundation, but currency accounts in the most important currencies have been set up at the bank and this significantly reduces the risk. Historically, the board has seen relatively small losses on accounts receivable, and the board is expecting this situation to continue. The customer base is largely made up of major, financially sound customers both nationally and internationally.

The company’s prospects

The board is expecting the financial situation for the foundation to continue to be tight. This applies primarily to the NUSP sector, which is expecting a significant deficit in 2014, including cost-reducing measures implemented. These measures will have a full impact from 2015. Continuing to operate with such as deficit presents IFE with a considerable financial risk.

The foundation’s estimated future pension liabilities in the Norwegian Public Service Pension Fund, amounting to NOK 316 million as at 31.12.2013, is another significant challenge facing the enterprise in future. The Board and Administration have started a process in 2014 in order to assess the current scheme and provide impact data relating to alternative pension schemes.

The income statement and balance sheet with associated notes show the financial operations and position of the foundation and Group as at 31 December 2013. Nothing has taken place since that time which would be of significance to the evaluation the foundation and Group.
Continued operation
As at 31.12.2013, the foundation’s equity is negative as a consequence of the negative results for the year and recognition of future pension liabilities; cf. above.

Specific measures should reinforce the financial situation within the foundation, primarily with regard to operations in the NUSP sector and the Halden Project. This is being done by means of cost savings, increased sales efforts in the bilateral programmes, and the management’s initiative for increasing contributions for a new three-year period in the Halden Project (2015-2017) from both participating foreign companies and the authorities in Norway. The Board considers it absolutely crucial to put in place sustainable finances for the NUSP sector in order to ensure ongoing operation and development of the foundation. To succeed with this, the Halden Project has to continue for a new three-year period (2015-2017) and the Government has to issue a new licence for the Halden reactor.

IFE is currently undergoing an extensive change process in order to shore up the Institute’s finances. The “A new IFE” project was launched in 2013 and focuses on profitability, better project management and cost reductions. There has been significant downsizing, merging of administrative functions and significant reduction of the Institute’s cost base up to now as part of this process. More efficient invoicing procedures, cost reductions and postponement of investments have reinforced IFE’s liquidity in 2014. Given the measures implemented, including downsizing and positive budgets and results achieved in 2014, the Board confirms that the criteria for ongoing operations are present. The Board takes this as its basis for the 2013 annual accounts.

Personnel
IFE is known for providing a good, stable work environment. The Institute works actively, purposefully and systematically to promote equality, guarantee equal opportunities and rights, and prevent discrimination based on sex, ethnicity, religion and faith.

There must be no discrimination at IFE due to disability, and the Institute works actively and purposefully to design and arrange the physical environment in such a manner that the various functions within the enterprise can be used by the majority. Work areas and tasks are customised for employees or applicants with disabilities.

The Institute has a multicultural work environment, with employees from 31 different nations. This provides a diversity which enriches IFE both professionally and socially. This mix of employees makes it easier for new staff with less experience of Norwegian culture to adapt to working life in Norway. This is a competitive advantage in respect of recruitment at the Institute.

As at 31 December 2013, the Institute had a total of 586 permanent employees, compared with 576 one year ago. Of these, 198 (202) are Higher Education personnel, of whom 28% are female. 75 (81) have doctorates, of whom 16 are female. The Board sets great store by the Institute’s prioritisation of equal opportunities work throughout the entire organisation. The Institute has 8 adjunct professor positions associated with the University of Oslo, the Norwegian University of Science and Technology and the University of Western Cape, Imperial College London, 2 inverse adjunct professor positions from the University of Oslo, 1 from the University of Oslo/Idaho National Laboratory and 1 from the Norwegian University of Science and Technology, 1 associate professor from the University of Oslo, 1 from the University of Oslo/the University Graduate Centre, 1 from the University Graduate Centre and 1 from the Norwegian University of science and Technology. The Board sets great store by the fact that it is important for IFE as a research institute for employees’ skills to be maintained and renewed. In 2013, 22 members of staff left and 36 new staff were taken on. A total of 3 foreign guest researchers remained at IFE for varying lengths of time in 2013.

As a consequence of the financial situation at the NUSP sector, a downsizing process took place within the sector in the first quarter of 2014. Key to this process was the requirement that the downsizing initiative was not to jeopardise safety work at IFE.

There have been some new appointments despite the downsizing process. These appointments related to critical functions for operation and increased earnings.
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