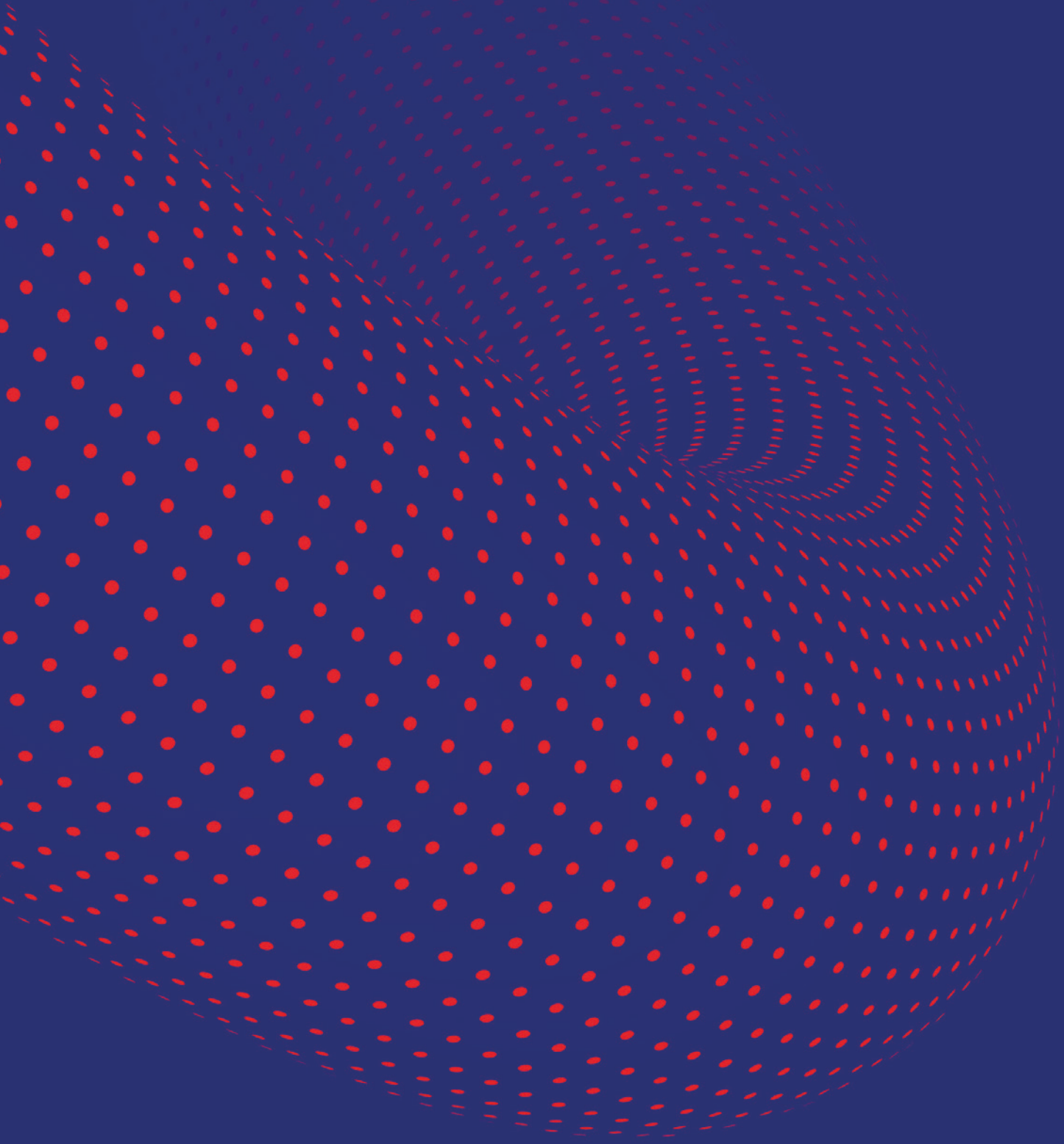
IFE

Research for
a better future

YEAR 2018

www.ife.no



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About IFE

The Institute for Energy Technology (IFE) conducts research for a better future. Since 1948, we have been a frontrunner in international energy research. The knowledge we have developed has saved the petroleum industry several hundred billion kroner. We have contributed to the development of ground-breaking cancer medicine, new solutions in renewable energy, more energy-efficient industrial processes, zero-emission transport solutions and future-oriented energy systems.

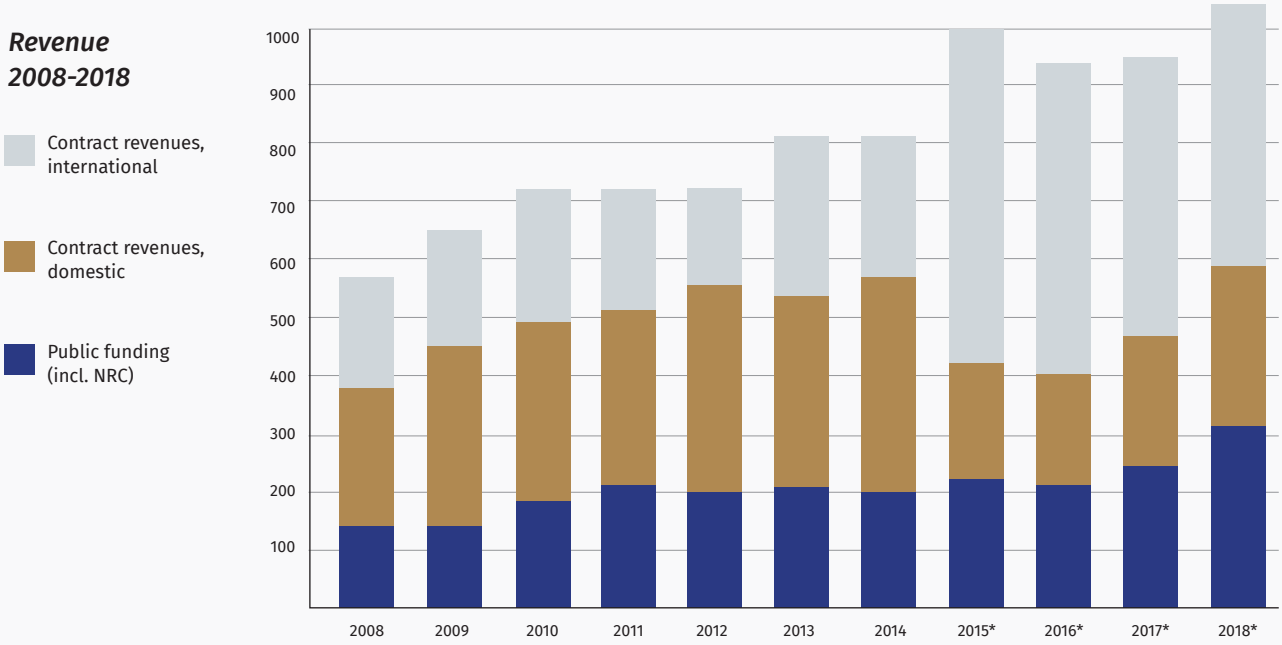
Our research and expertise have led to safer use of nuclear power, and we have developed methods for verifying the disarmament of nuclear weapons. The research at IFE has created jobs in Norway, facilitated business development and generated important expertise for the Norwegian trade and industry sector.

At IFE, we build bridges between research, education and industry. We have extensive infrastructure and full-scale laboratories where theoretical models are transformed into commercial activities. IFE has unique expertise and systems within radiation protection and environmental monitoring of radioactive and chemical emissions. This makes us an important partner for companies that want to research, develop and produce new solutions for renewable energy and medicine using radioactive sources.

The digitalisation of society is seeing the emergence of a new era. IFE has broad digital expertise and contributes to quality assurance and efficiency improvements for customers in the public sector and in trade and industry. When the next chapter in Norway's history is written, it will be about how we adapt. We must create new and sustainable jobs. At IFE we have already begun – we are conducting research for a better future.

Key figures

Revenue 2008-2018



	2008	2009	2010	2011	2012	2013	2014	2015*	2016*	2017*	2018*
Contract revenues, international	210	202	233	243	229	267	324	571	522	484	461
Contract revenues, domestic	224	287	307	303	355,6	324,5	367	191	199	212	290
Public funding (incl. NRC)	158	167	184	211	201	217	210	231	225	243	323

The change in domestic and international revenues from 2014 to 2015 is due to the reclassification of revenues from the Xofigo production. In 2015 and subsequent years, approximately 200 MNOK related to Xofigo was classified as international contract revenues instead of domestic revenues.

IFE's vision:

A leading international research institute

1 billion

Turnover

Annual scientific publications

142

No. of employees

600

Nationalities: 38

Researchers: 226

PhDs: 105

24

Advanced laboratories

International projects

>200

2

Centres for Environment-friendly Energy Research (FME)

Anniversary and the end of an era – 2018 an exceptional year for IFE

The year 2018 will go down in IFE's history as a year of major milestones, but also a year that signifies a crossroads and a change of course. In 2018, we marked two significant anniversaries: 70 years since IFE's inception and the 60th anniversary of the Halden Reactor Project. We celebrated IFE's unique and proud history with small and large celebrations throughout the year, and a formal anniversary celebration was held for all employees in November.

When we look back and sum up our 70-year history, there is no doubt that the knowledge, innovations and developments at IFE have created significant values for Norway and its trade and industry sector. IFE's knowledge and technology have improved safety, the environment and energy efficiency in Norway and abroad.

According to an estimate by Rystad Energy, the multi-phase technology OLGA, which is based on source code for the modelling of two-phase flow in the reactor's coolant circuit, has created values of NOK 1600–2000 billion on the Norwegian continental shelf and the international continental shelf. This represents an incredible sum, and offsets all public spending on research many times over.

Our nuclear expertise in medicine and radiopharmaceuticals has created over a hundred jobs and enabled us to produce and develop new cancer drugs in close collaboration with the pharmaceutical industry. IFE is at the very forefront of the pursuit for the next generation of battery technology, and our researchers are helping to improve solutions for solar and wind energy and hydrogen systems in combination with smart digital solutions.

Decision on the Halden Reactor

2018 also marked a major crossroads for IFE. In June, IFE's Board of Directors decided to shut down the Halden Reactor, following an impressive almost 60-year history of research on safer nuclear fuel.

The reasons behind the decision to shut down the reactor were complex. The Halden Reactor had been running at a loss for several years, and in March 2018, a faulty safety valve was discovered during a routine maintenance inspection. Restarting the reactor would require extensive investment. Following an overall assessment, the Board therefore concluded that the reactor should not be restarted and that no new operating licence should be applied for

The end of the Halden Reactor is by no means the end for IFE or for our nuclear research. IFE maintains its strong commitment to research and activities in Halden that are not dependent on the reactor. The phasing out of the reactor and the handling of nuclear waste will take several decades, and IFE's extensive knowledge and expertise, including in the field of decommissioning, will be needed to ensure a safe and cost-effective shutdown. after 2020.

Change is the only constant

IFE has always changed and adapted with the times. Halden is now entering a new chapter, within decommissioning and expansion of the research and services on digital systems. Although it has been decided to decommission the Halden Reactor, the project will continue with an emphasis on the digital MTO (Man-Technology-Organisation) research, where digital solutions are developed based on a human-centred design.

We will also continue one of the Halden Reactor's many tasks over the past 60 years: making reactors throughout the world safer. We have established a large and unique database resulting from almost 60 years of experimental research on nuclear fuels. We are now considering the possibilities for new ways of applying these data, through the use of digital solutions with big data, artificial intelligence and machine learning. Our experts in Halden are highly regarded by our international partners and networks, and the members of the Halden Reactor Project have indicated that they want to continue the cooperation.

Today, IFE is a leading research institute in nuclear technology, renewable energy, oil and gas, health, digitalisation and industrial development. We are well positioned to meet the major challenges facing the world; climate challenges, urbanisation, the ageing population, digitalisation, and how to realise the transition to renewable energy and zero-emission technology. Knowledge and technology are key to solving these challenges.

Continued focus on safety and safety culture

In 2018, IFE continued its targeted efforts to improve safety and the safety culture. IFE's activities require a high standard of safety and a healthy safety culture, and we always seek to improve and to align ourselves with best practice and to draw on the experience and knowledge of international leaders in the field. At the request of IFE, the IAEA conducted a review of the safety culture at IFE in 2018. This has made an important contribution to the safety efforts at the institute.

Norway was the sixth country in the world to establish a nuclear reactor and has conducted research on nuclear fuel since the 1950s as part of the Halden Reactor Project. Management of the waste from this activity is a very complex task bacause the waste consists of many different types of radioactive materials with a variety of compositions. A total of almost 17 tonnes of spent fuel has been produced in Norway. In 2018, an additional four tonnes of other radioactive waste was stored at IFE. This is waste that cannot be deposited in the National Combined Disposal and Storage Facility (KLDRA) at Himdalen in Aurskog-Høland municipality.

In 2018, IFE investigated and planned several activities related to the continued clearing up of nuclear waste, and projects were initiated in a close dialogue with the Norwegian Nuclear Decommissioning Authority (NND). Preparing for the permanent disposal of Norway's nuclear waste is a very comprehensive and complex task, and Norway will be dependent on IFE's expertise, experience and infrastructure within this area for many decades to come.

Openness and transparency

IFE's nuclear research activities afford us a unique position and responsibility. We therefore consider transparency and openness related to our activities to be an important aspect of our social mission and crucial to IFE's reputation. In 2018, we strengthened the work within communication and public relations. We have now adopted a more active approach to the media and social media, which enables us to disseminate information about and explain our research and nuclear activities. We have also strengthened our efforts in privacy protection and appointed a privacy policy advisor to follow up this work.

Innovation and market

In 2018, we increased our innovation and market development activities, with good results. Over the years, IFE has established a number of new businesses and jobs on based on our research. In 2018, we strengthened our focus on innovation and commercialisation further. IFE Invest AS is a wholly-owned investment company that establishes and develops companies based on technology developed at IFE, and as an active owner provides support for daily management, market development, upscaling and capital injections.

In 2018, the IFE spin-out company Restrack was sold to Resman, which is based in Norway. The sale demonstrates IFE's ability to transform research and technology into robust growth companies. The company Sunphade was formed in 2018 from IFE's Solar Energy Department. We have also strengthened our efforts aimed at the EU's Horizon 2020 research programme through a new position to head and coordinate IFE's EU-related activity. Within a short period of time, this activity has yielded good results in the form of more EU application approvals. Among other things, IFE has been given the role of coordinator in an EU project for the new and environmentally friendly production of alumina from the raw material anorthosite. The project is based on innovative technology for the sustainable production of alumina, which IFE and Nordic Mining have patented, and has a total budget of 6 million Euro.

In order to solve the challenges of the future, IFE will continue to recruite talented students. We are therefore pleased to report that IFE maintains a good position as an attractive employer. In 2017, IFE climbed to 11th place in the Career Barometer's ranking of the most attractive employers in Norway, and in 2018 we retained this position.

IFE has been conducting research for a better future since 1948, and never before has our research been more relevant to society than it is now.

Nils M. Huseby, President

Organisation chart as of 31 December 2018

PRESIDENT
Nils Morten Huseby

SERVICES & INFRASTRUCTURE
Atle Valseth

HMS & SECURITY
Helena Broberg

STRATEGY, ORG. DEV. & COMMUNICATION
Silje Aspholm Hole

Divisions

RESEARCH AND DEVELOPMENT

RADIOPHARMACY
Erik Flatmark

NUCLEAR TECHNOLOGY

Sectors

DIGITAL SYSTEMS
Tomas Nordlander

FLUID FLOW & ENVIRONMENTAL TECHNOLOGY
Martin Foss

MATERIALS AND PROCESS TECHNOLOGY
Arve Holt

RADIOPHARMACEUTICAL PRODUCTION
Kari Harbak

RADIOPHARMACEUTICAL WHOLESALER
Silje Sivesind

RADIOPHARMACEUTICAL R&D*
Bente Tange Harbø

NUCLEAR TECHNOLOGY, PHYSICS & SAFETY
Nils M. Huseby

NUCLEAR WASTE MANAGEMENT & DECOMMISSIONING
Henning Refshauge Vahr

** Radiopharmaceutical R&D falls under both the R&D division and the Radiopharmacy division.*

IFE's strategic research focus

Strategic focus: **Renewable energy**

The global energy market is in transition. We are moving away from centralised energy supplies from nuclear, gas and coal power, towards more distributed energy production based on renewable energy sources such as hydro, solar, wind, bio and geothermal energy. This shift is leading to a major upward trajectory in megatrends in all these areas, particularly in wind and solar energy, as well as energy storage using batteries and hydrogen. All global trends in renewable energy point towards an upward development for a long time to come. This is supported by the IEA's World Energy Outlook, Equinor's Energy Perspectives, the Norwegian National Transport Plan and the EU's Energy Roadmap 2016–2050.

IFE has a strong position in solar energy, renewable energy systems, batteries and energy storage. The institute has considerable growth potential in bioenergy, hydrogen systems, wind and, to some extent, geothermal energy. We are developing new solutions and products for both the private and public sectors, mainly within the renewable energy market segments, as well as in the materials and process industries.

Strategic focus: **Health**

Menon has examined the added value in Norway's healthcare industry, and documented that this industry is experiencing strong growth in terms of turnover and R&D activity. Since 2014, the healthcare industry has grown by an average of NOK 4.5 billion per year.

IFE's position in the healthcare industry
IFE has been developing radioactive medications since the 1950s. IFE is the sole distributor of radiopharmaceuticals to the Norwegian market. We serve as a central 'isotope pharmacy' for Norway and control all radiopharmaceuticals and distribute them directly to Norwegian hospitals. The import and distribution of short-lived products that are not yet produced in Norway is another important area of activity.

We are part of the Oslo Cancer Cluster, where we help to initiate clinical trials of pharmaceuticals. We are part owners of Catapult Life Science and share their ambition to aid the development of new pharmaceuticals through our expertise in process, production, analysis, quality assurance and regulatory issues.

IFE has good working relationships with key industry players such as Bayer, Nordic Nanovector, Oncoinvent and Scatec/Thor Energy. In addition to the unique expertise gained through the radiopharmaceutical activity, parts of the energy research can be applied to the area of health. For example, the calculations used in complex piping systems for the oil industry provide the basis for applications that involve the human body and blood circulation. The IFE researchers who have worked on petroleum extraction are now involved in activities where hospitals and the pharmaceutical industry are customers and partners.

IFE possesses extensive expertise in materials and particles, which has so far been used in solar cell technology. These are research areas that can also be applied to the development of pharmaceuticals.

Our ambitions with the focus

IFE wants to help 'close the gap' between academia/hospital researchers and industrial production, and in doing so create new jobs and contribute to innovation and adaptation.

Our ambition is to aid the development of new pharmaceuticals through the expertise we have in process, production, analysis, quality assurance and regulatory issues. We also aim to apply more of the energy research to the field of health care.

Strategic focus: **Digitalisation**

Access to large volumes of data, the internet of things, data analysis, machine learning and learning algorithms create potential for disruptive innovation in digitalisation. IFE has a strategic focus on digitalisation with a view to becoming the leading research institute in this area.

IFE was a pioneer in Norway within IT and has been supplying IT solutions to Norwegian industry since the late 1960s. IFE now has one of the largest digitalisation research communities in Norway. We have experts with extensive expertise in major, important international growth areas such as wind technology, solar technology, process industries and fluid flow technology. In addition, we have extensive experience in the practical application of new digital technology.

IFE's strategic focus on digitalisation began in the autumn of 2018. IFE has been working with digital technology since the late 1960s, and has extensive expertise in using digital technology to solve challenges and facilitate development in the trade and industry sector.

Photo: Espen Solli

As part of the digitalisation initiative, IFE will focus on industry 4.0, smart cities, health, transport, decommissioning and agriculture.

Through the OECD's Halden Reactor Project and bilateral projects, IFE has been providing IT solutions to the international nuclear power industry for almost 60 years. On the Norwegian continental shelf, IFE has supplied control room systems for numerous offshore platforms.

IFE aims to be a desirable partner for industry and academia, but also to be an attractive employer in order to recruit and retain the best talent. This will put us in an even stronger position to exercise influence and define areas for Norway's transition towards greater digitalisation. Our ambition is to better equip Norwegian trade and industry and the country's public sector to thrive in the new digital world.


ife
VIVE
VIVE

Sector

Materials and Process Technology

Through research and development, this sector will contribute to a better society and cleaner environment by serving as a leading resource centre within renewable energy and environmentally friendly industrial processes. We will achieve this by enabling IFE's customers and spin-off companies to apply improved or new processes and methods. We develop new solutions and products for the private and public sectors, mainly within renewable energy and materials and process industries.

Materials and Process Technology has around 60 employees (researchers, engineers and coordinators), as well as approximately 20 doctoral and postdoctoral researchers. Turnover in 2018 was NOK 194 million, with a profit of NOK 6 million.

The sector consists of six departments:

- Solar energy
- Battery technology
- Renewable energy systems
- Neutron materials characterisation
- Computational materials processing
- Environmentally friendly industrial processes

The sector is currently conducting research in renewable energy systems, solar energy, batteries and hydrogen as future energy carriers, new energy materials and nanotechnology, advanced neutron materials characterisation, and environmentally friendly industrial processes.

Our main revenue is generated from the research and development of new solutions and products for both the private and public sectors.Many of our projects involving expertise and innovation are co-funded through the system of policy instruments in the Research Council of Norway, ENOVA and the EU programme Horizon 2020, together with the business sector.

To aid our research, we have an advanced infrastructure that includes, inter alia, laboratories that undertake the following:

- Production of silicon-based solar cells, with the associated characterisation and analysis equipment
- Production of materials for use in solar cells and batteries
- Production of materials for CO2 capture for use in hydrogen and energy production processes
- Development and testing of batteries
- Production of hydrogen through reforming or electrolysis
- Development of the hydrogen systems of the future
- Advanced neutron materials characterisation
- Advanced simulation and modelling platform for use in the development of new kinds of materials processing

The sector hosts two of Norway's eight new Centres for Environment-friendly Energy Research (FME): FME Research Centre for Sustainable Solar Cell Technology (SuSolTech) and FME Mobility Zero Emission Energy Systems (MoZEES).

We are partners in three other FME centres: one in bioenergy (Bio4Fuels) and two within the social

sciences (CenCes and CREE). In addition, we are involved in over 100 other ongoing projects with external partners, to the tune of NOK 0.5–10 million.

Highlights in 2018

2018 has been a successful year for the sector, both professionally and financially. The sector has experienced major growth in the project portfolio, particularly within battery technology and renewable energy systems. The research findings have resulted in, among other things, 75 international articles and numerous positive reviews in the media. We have also given more than 100 presentations at international conferences. In addition, we have delivered new solutions that improved our customers' competitiveness and created added value for them. Based on our own technology, we have also started two new commercialisation projects, SiliconX and SunPhade. IFE is also coordinating a large mineral refining project that is co-funded by Horizon 2020, with a total budget of NOK 24 million for IFE. The purpose of this project is to produce alumina (Al_2O_3), silica (SiO_2) and $CaCO_3$ from a mineral, where the use of CO_2 plays an important role. This project, AlSiCal, will start in 2019.

Market outlook

The global energy market is going through a major shift away from centralised energy supplies using nuclear, gas and coal power towards a more distributed energy production based on renewable sources such as hydro, solar, wind, bio and geothermal energy. This shift is leading to a major upward trajectory in megatrends in all these areas, particularly in wind and solar energy, as well as energy storage using batteries and hydrogen. IFE is well positioned to take part in this growth.

In the materials and process industries, there will always be a need for materials with new types of properties. IFE is well positioned within this segment due to our powerful simulation and modelling tools, our ability to produce brand new materials using our expertise in nanotechnology, and our knowledge of industrial processes.

The market situation for the sector is very favourable, with a good supply of new projects which are either funded solely by the business sector or co-funded through the system of policy instruments. The sector had a healthy economy in 2018, which resulted in a profit of NOK 6 million – despite the high costs of our advanced laboratories and particularly the instrumentation associated with JEEP II, Hynor, the solar cell laboratory, the laboratory for production of energy materials and the battery laboratories.

Photo: Espen Solli


Rune Sandenå
Forsker

Centres for Environment-friendly Energy Research (FME)

Centres for Environment-friendly Energy Research (FME) is a programme under the auspices of the Research Council of Norway, with up to 8 years of support for Norwegian research centres of a high international standard in research on environmentally friendly energy. IFE hosts two FME centres; MoZEES and SuSolTech.

MoZEES - Mobility Zero Emission Energy Systems

The purpose of MoZEES is to contribute to the development of new battery and hydrogen materials, components and systems for existing and future use in the transport sector on roads, rails and seas. The research centre will contribute to the design and development of safe, reliable and cost-effective zero-emission transport solutions. The centre also has a strong focus on education. A minimum of 13 doctoral students and 5 postdoctoral fellows will conduct research at the centre.

The focus areas for the research at MoZEES are as follows:

1. New materials and processes for industrial niche markets for batteries and hydrogen
2. Battery and hydrogen components and technologies for products aimed at the export market
3. Battery and hydrogen systems for application in existing and new transportation markets (road, rail and sea), with a special focus on maritime applications
4. New systems solutions and services, with a focus on sustainable and techno-economic navigable roads and zero emissions in the transport sector.

The centre is a collaboration between four research institutions: IFE (host), SINTEF, the Institute of Transport Economics (TØI) and the Norwegian Defence Research Establishment (FFI), in addition to three universities (UiO, NTNU and USN), seven public sector partners, three private interest groups and 22 business and industry partners, including suppliers of materials, key components, technology and systems within batteries and hydrogen.

Highlights in 2018

MoZEES held a number of meetings and workshops in 2018 with internal and external partners. In February, approximately 30 participants attended the MoZEES Battery Days 2018 workshop on the topic of batteries, which included an open battery laboratory course at IFE Kjeller. This will be an annual event. MoZEES also contributed to the organisation and the talks given at an international workshop on transport (Energy Transition Conference 2018) in March and an international conference on hydrogen and fuel cells (H2fc2018) in May, both held at NTNU, Trondheim.

Four new doctoral students joined us in 2018; one at UiO (with FFI) who is focussing on the development of new high-voltage cathode materials for batteries, two at NTNU who are working on market development for new technology in the transport sector and bipolar plates for alkaline water electrolysis respectively, and one at UiO who is focusing on composite membranes for PEM fuel cells. In addition, a postdoctoral fellow has been employed at IFE (with UiO) to perform various life-cycle analyses and another one is working at UiO to develop diagnostic techniques for Li-ion batteries.

FORSKNINGS-
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ENERGI

Norges forskningsråd

There are now 9 doctoral students directly affiliated with activities in MoZEES. All students whose main supervisor is at NTNU, UiO or USN also receive supervision from other research and industry partners in MoZEES.

The MoZEES Research Training Network (RTN), headed by UiO, was established to support our young researchers. The young researchers come together to get to know each other and key research and end-user partners. The aim of this initiative is to generate synergies across the work packages and to add to the relevance of the research. MoZEES RTN has created its own website, which includes a presentation of the members and a blog run by the network itself. MoZEES RTN has also established a mobility programme to promote exchanges with international research partners and end-user partners in the centre. In 2018, one of the doctoral students had a three-month visit to BASF in the USA under the programme. A scientific committee was also established, consisting of four internationally recognised professors and researchers (from Sweden, Germany and the USA) to assist the Board, management and doctoral students in MoZEES with strategically important scientific choices. The first meeting of the Board, the scientific committee and MoZEES RTN was held in mid-September.

SuSolTech - Research Centre for Sustainable Solar Cell Technology

SuSolTech was established in 2017 and brings together leading research groups in Norway with major players in the solar cell industry from Norway and abroad. Today, the solar cell industry is completely dominated by silicon-based solar cells, which we expect will continue to be the case for many years to come.

A shift to a more sustainable energy system based on renewable resources will therefore depend on access to an increasing volume of sustainable silicon materials, ingots and wafers that enable the production of ever-more efficient solar cells, solar panels and solar power systems.

The anticipated further growth in the solar cell industry represents a huge commercial opportunity, including for Norwegian companies. Silicon materials for global use in industry are a Norwegian industrial speciality. The centre helps to strengthen these companies in a competitive industry through the development of new production processes that enable cleaner production, lower costs and a higher quality of materials. The centre achieves this through research along the entire value chain.

The centre monitors the production in solar cell plants in order to demonstrate the effect of the planned development of materials and processes on both the environmental footprint and the costs. The activity in solar cell plants supports a rapidly expanding industry in Norway within the field of installation and operation. This industry is expected to grow further in the years ahead.

The centre is also partnered with companies that are not currently considered to be part of the solar cell industry, such as organisations, architectural firms and energy companies. These draw on the centre's broad expertise in order to develop new business opportunities. The FME SuSolTech centre will be the main national focal point for expertise and innovation within the growing solar power industry in Norway up to 2025.

Photo: Espen Solli

Sector

Fluid Flow and Environmental Technology

IFE Fluid Flow and Environmental Technology is an industrial-oriented sector that mainly works in oil and gas, wind energy and environmental technology. The sector's projects have a significant element of purely industrial projects that reflect the relevance of the sector's research for Norwegian and international industry. Researchers in the sector have been developing digital tools for the Norwegian petroleum industry for more than 30 years. The development of OLGA symbolises what is perhaps the most important innovation in the Norwegian research industry in modern times. OLGA is a modelling tool for the transportation of oil, gas and water in the same pipeline, known as multi-phase transportation. The multi-phase technology was voted the most important Norwegian invention since 1980 by a panel of experts at the newspaper Aftenposten.

Turnover is approximately NOK 106 million, and the sector has 70 employees in a total of five departments:

- Corrosion technology
- Flow engineering
- Wind energy
- Tracer technology
- Environmental analysis

In 2018, the sector has worked to affirm its position as world leader in the field of fluid flow technology and corrosion in the oil and gas sector. These are traditionally strong areas in which IFE holds an important international position.

The steady supply of industry-driven key projects in 2018 confirms that the sector's departments are valuable international partners in these fields. In addition to this, the sector has also focused on recapturing its position as Norway's most important contributor to the field of tracer technology in 2018. IFE has been at the forefront of tracer technology for more than 20 years, but faced challenges following the oil market crash in 2014. We are now on our way to once again becoming a leading premise setter in this area too. This is exemplified by our position as one of the main partners in the SFI's National IOR Centre of Norway, along with the University of Stavanger and NORCE. In 2018, IFE also sold its stake in Restrack, which makes us a more neutral partner and one that is attractive for international companies to work with directly.

In addition to the specialist areas that are mainly associated with oil and gas, the sector also has a significant focus on wind energy, geothermal energy, floating structures and environmental technology. IFE has long been a leader in aerodynamics in Norway, particularly in relation to offshore wind energy. This expertise has resulted in spin-off companies such as Kjeller Vindteknikk, which is a major player in the field of wind measurement and analysis. The sector also has a long-term commitment to further develop the work on floating structures, and our 3DFloat simulation tool affords us a major competitive advantage.

In addition to wind energy, the sector is in the process of escalating its environmental technology activities. Our extensive expertise in analysis gives us a significant competitive advantage and will enable us to develop IFE as a pivotal environmental technology arena in collaboration with other players in the Greater Oslo region. IFE has a special focus on developing the work on fingerprinting based on isotope analysis, and an ambition to be the market leader in this type of analysis and research.

The sector also has a focus on carbon capture, transport and storage (CCS). Through its work in multi-phase transportation and corrosion in CO2 pipelines, the sector has accumulated unique expertise and is an important contributor to CCS in Norway. The sector's departments have developed a unique infrastructure that forms much of the foundation for research in this field. The laboratory for controlled CO2 impurities analysis is one of the world's leading laboratories for this type of testing. The sector helps Norwegian industry to be more competitive in a globalised market and to develop more sustainable solutions. The sector has two new focus areas; environmental monitoring of repositories and landfills, and patient-adapted health care. This work will represent a new diversification of operations in the coming decades, whilst also addressing the challenges facing industry and the public sector both home and abroad. In order to maintain an interdisciplinary approach and safeguard the development of robust expertise, these initiatives are closely linked to the existing activities.

Highlights in 2018

The most important single event for the sector in 2018 was the sale of Restrack AS to Resman. This creates new potential for the Tracer Technology Department, which we will now focus our efforts on. The sale was also a good example of the oil and gas market trends in 2018 that made it easier to secure partners in new projects. In 2018, IFE entered into a strategic partnership with NCE Subsea Valley and BI Norwegian Business School. Through this collaboration, IFE, NCE Subsea Valley and BI will highlight Greater Oslo as an energy region in Norway.

Among the projects the sector secured, some key projects can be highlighted.

IFE's leading expertise in offshore wind turbine simulations can be applied to many other structures exposed to wind and waves. Our 3DFloat simulation program has proved to be one of the best tools for simulating floating bridges, and has helped us to win a large contract with the Norwegian Public Roads Administration, together with Norconsult and Dr.techn. Olav Olsen and others, for the E39 floating bridge over Bjørnafjorden. Winning this public tender shows that we can help our partners to be competitive, including in national projects. Together with NGI, NTNU, Equinor, Dr.techn. Olav Olsen and Vattenfall in the Redwin project, we have developed longed for and greatly improved engineering tools for simulating the interaction between fixed offshore wind turbines and the seabed. This can yield significant cost savings for the entire industry and represent a significant step forward.

IFE's leading role in corrosion in flexible pipes is reflected in the Kjeller Flexible Cracking I (KFC-I) project. This is a new Petromaks 2 project, which started in 2018 and focuses on crack formations in flexible pipes used in oil production.

The project has a strong international participation, with contributors such as TechnipFMC in France, Chevron in the USA and Petrobras in Brazil.

IFE is also part of a collaborative project with 4Subsea and the Federal University of Rio de Janeiro that focuses on corrosion in flexible risers in Brazil.

The G-Cool project, with funding from EUROSTARS, was started in 2018 in collaboration with three Spanish partners. Its focus is on developing nano-fluids to improve cooling in high-performance engines in MotoGP racing. The new coolants will initially be tested on a MotoGP motorcycle, as well as a Norwegian drag race car. This work will be trialled in other industrial applications where efficient and compact cooling is important.

IFE also had success within CCS in 2018, as represented by our two CLIMIT Demo projects; KDC-III and CO2WELLMAT, which focus on corrosion in CO2 pipelines and injection wells for CO2. We are also a subcontractor for the CLIMIT Demo project CO2Fact, which focuses on fluid flow. Winning CCS projects is important for IFE and affords us the position we need to continue developing our CCS laboratories, which are world leaders in their fields.

IFE is now developing the next generation of the Tracer Club. This project is the cornerstone of the efforts to develop new tracers for industry that will lay the foundation for future EOR (enhanced oil recovery) projects. The project is a JIP (joint industry project) with industry funding, which reflects the industrial relevance of the project.

Market outlook

The sector is still feeling the effects of the fall in oil prices in 2014. Consequently, companies have been more hesitant to participate in research projects, which resulted in fewer contracts being signed in 2018 than in previous years. Several oil companies have also changed their strategy; they are now more likely to allocate funds on a year-to-year basis and refrain from participating in long-term research projects in the oil and gas sector. This reduces predictability in the sector and increases the need for Research Council-funded projects outside the field of petroleum. However, over the past year, the sector has seen a resurgence of enquiries from oil companies, and the volume of work in oil and gas seem to be increasing. The sector will continue its strong focus on relevant oil and gas research projects for Norwegian and international partners.

Oil companies are also investing in new areas, and the sector's work in wind energy, geothermal energy and the environment will have major growth potential for collaborative efforts with traditional partners in the years ahead. Developing a network of public sector actors such as inter-municipal enterprises and local authorities will be a strong focus area.

The market for health technology is also a focus area for IFE in the years ahead. This market is experiencing strong growth and is mainly rooted in the Greater Oslo region. Through our current efforts in building networks with the university hospitals in Oslo and Akershus and various start-up companies, IFE will create new opportunities and use our expertise to contribute in a growing market.

Sector

Digital Systems

This sector researches areas that are complex and of critical importance to society in relation to digitalisation, with a special emphasis on digital transformation and security. Turnover is approximately NOK 112 million and the sector has 69 employees in six departments:

- Risk, safety and security
- Virtual and extended reality
- Intelligent systems
- Control rooms and interaction design
- Human-centred digitalisation
- Automation and user monitoring

IFE hosts the Halden Reactor Project for the OECD/NEA and approximately half of the sector's revenue stems from these projects. The sector handles all projects that involve interaction between people, technology and organisation, and safety in complex process industries. In addition, we generate revenues from international and national contracts. The sector is working strategically to increase the proportion of research projects (EU, Research Council of Norway, etc.) in the project portfolio. In addition, it is seeking to boost expertise from areas such as intelligent systems, machine learning, visualisation and big data, which has been gained from the Halden Reactor Project, and to use this in other areas than nuclear power.

Highlights in 2018

New technology and digitalisation are leading to fundamental changes in all industries and activities, both in the public and private sectors. There is a growing need for digital solutions and services, and we have developed our strategy to identify in which areas of digitalisation we want to strengthen our positions. 2018 has been a year of great change in the sector. We have had a strong focus on publications, research applications and transparency in addition to network building. The changes IFE has experienced, such as initiation of the decommissioning process at the Halden Reactor, have affected the Halden Reactor Project, which the sector depends on. Despite all these changes, 2018 has been an exceptional year for IFE. We have doubled the number of publications compared with 2017, and a considerable number of our research applications have been successful. Cybersecurity activities have shown strong growth. The IAEA has approved IFE as a Collaboration Centre in the field of nuclear decommissioning, and the Research Council of Norway has approved decommissioning research projects. The sector has also held numerous workshops, both internally and externally, with a focus on safe decommissioning and phasing out of nuclear power plants, for example.

Market outlook

The Digital Systems sector designs efficient control rooms for different clients, such as railways, remote-controlled control towers and nuclear power stations. One example is the design of control rooms for the European Spallation Source (ESS) in Lund, Sweden, one of the world's largest scientific and technological infrastructures currently under construction. We develop software, such as

Photo: Espen Solli

VR software, for the design of control rooms and software that is used for the safe decommissioning of nuclear power plants in several countries.

We assist businesses with assessment of risk, safety and security needs. We use machine learning and big data to assist companies with condition monitoring, maintenance, automation and user monitoring. We assist contractors with organisational design, enabling them to effectively implement digital technology and analysis tools that provide support in complex decisions.

For many years, around half of the sector's turnover has been generated by the Halden Reactor Project. This has enabled us to develop skills that are highly relevant – and often unique – for helping organisations with their digital adaptations. However, for a long time this revenue has made us less dependent on submitting research applications. In addition, the Halden Reactor Project's publications are in the form of reports that are reserved for member organisations. This means that our research has been less visible than that of other research institutes.

In 2018, the sector increased the number of research applications in order to increase the proportion of funds from the EU and the Research Council of Norway. We will maintain this focus in 2019.

Our unique expertise in some areas of digitalisation, such as human-centred organisational design, IT risk and security, design of control rooms and alarm systems, automation and machine learning, means that we are well positioned to assist other enterprises with research and development, and restructuring processes. We have extensive experience in complex processes within nuclear activities, where safety requirements are very strict. This gives us a competitive edge when meeting new industrial clients as well as public sector actors.

Division

Radiopharmacy

The Radiopharmacy division was established on 1 May 2018 and has a staff of approximately 140. Turnover in 2018 stood at NOK 330 million. This division works with radioactive medications (radiopharmaceuticals) and has the following key areas:

- Contract production of radioactive medications for commercial and clinical use
- Control and distribution of radiopharmaceuticals in Norway and internationally
- Research and development in radiopharmaceuticals

Radioactive medications are used to create images of organs and lesions, and to treat various diseases, such as cancer.

The increasing need for radiopharmaceuticals offers considerable growth potential, both in Norway and globally. IFE's Radiopharmacy division has wide-ranging expertise and an infrastructure for the development, production, control and distribution of radiopharmaceuticals that places us in a unique position to take part in global growth.

IFE can support researchers and start-up companies with the pharmaceutical development of new medications, thus contributing to development work, commercial production and the creation of new health-related industries and new jobs in Norway.

IFE also safeguards the production of medications that are not commercially available on the market. We adapt products according to the particular needs of our clients, including radioactive labelling of peptides, proteins and other relevant substances for use in research and clinical studies.

The Radiopharmacy division has dedicated laboratories for the production, packing and quality control of radiopharmaceuticals. The laboratories are classified both in respect of purity classes in accordance with international GMP (good manufacturing practice) regulations and radiation protection legislation.

Radiopharmaceutical production
The sector is responsible for the production of radiopharmaceuticals for late-phase clinical trials and contract production of Xofigo® for Bayer. Xofigo® is a medication used to treat prostate cancer patients. The sector also participates in the division's development projects and provides quality control services.

Radiopharmaceutical wholesaler
IFE has produced radiopharmaceuticals since 1953, and since then has acted as a national pharmacy for radioactive medications. The sector is a wholesaler and retailer of radiopharmaceuticals in Norway. All radiopharmaceuticals to Norwegian hospitals are controlled and distributed through the Radiopharmacy division at Kjeller.

Our distribution activities ensure that Norwegian patients have access to good-quality pharmaceuticals at the right time through controls and traceability as well as validated and efficient transport routes. The sector is also a resource centre for the development and use of pharmaceuticals.

The distribution of radiopharmaceuticals for clinical trials nationally and globally as well as the distribution of our own products are key tasks. Importing and distributing short-lived products that are not yet produced at Norwegian PET centres is also an important area of activity.

Radiopharmaceutical research and development (R&D)
The sector's key tasks are to support start-up companies and research communities in developing radiopharmaceuticals from the early stages to clinical trials. This includes process development, analysis development and studies that are needed to document stability, robustness and reproducibility. Production of radiopharmaceuticals for early-phase clinical trials is an important task.

In the satellite in the Oslo Cancer Cluster Incubator (OCCI), the sector is involved in the development of cell labelling, and the labelling and bonding (chelation) of radioactive nuclides. The research communities at Oslo University Hospital (OUS) and the University of Oslo (UiO), as well as smaller new start-ups are all important partners.

The sector is the hub of IFE's strategic focus on health going forward in collaboration with the other research sectors at the institute.

Highlights in 2018

2018 has been a good year for the division, with a high level of activity and regularity in production. The good working relationship with Bayer has been expanded both in terms of Xofigo® and other products. The growing cooperation with other Norwegian pharmaceutical industries has also been positive. The cooperation with Nordic Nanovector, primarily in relation to the production for a major clinical trial programme and several other developmental tasks, looks particularly promising.

IFE Radiopharmaceutical Wholesaler has continued to develop its distribution expertise for radiopharmaceuticals and medications in general with a view to controls and traceability, validation of transported items and transport routes, and the handling of hazardous goods. In 2018, the sector has assisted in bringing a number of new PET radiopharmaceuticals to the Norwegian market.

The sector has also established distribution services for Oncoinvent.

The global pharmaceutical industry is expressing increasing interest in radiopharmaceuticals and the unique opportunities that lie ahead for us in the diagnosis and treatment of serious illnesses.

IFE and the Radiopharmacy division wish to play a key role in society's future investments in this field and plan to strengthen both capacity and expertise in order to be of relevance for partners, researchers and clinicians in the years ahead.

Photo: Bo Mathisen

IFE's nuclear research activities

Nuclear research activities comprise the Kjeller JEEP II research reactor, the Halden Reactor, other nuclear research facilities, Nuclear Material Technology, the Electron Beam and Workshops department in Halden and the Nuclear Waste and Decommissioning sector. IFE has a turnover of NOK 291 million and 149 employees in its nuclear research activities.

The JEEP II Reactor at Kjeller

The reactor makes it possible to 'see into' different materials in order to find out how atoms organise themselves. The main purpose of the Kjeller JEEP II Reactor is to produce and make neutrons available for research on new functional materials based on metals, composite materials and biological materials.

The JEEP II Reactor has been in operation since 1967 and forms part of the national research infrastructure for basic physics research and materials technology. Research on materials and nanotechnology requires experimental facilities, where different types of materials can be subjected to fundamental studies of atomic and molecular structure. In such a facility, information about the different materials can be obtained by beaming light or particles into the materials. Neutrons are unique in this context, and they provide information that is impossible to acquire in any other way. JEEP II is the only experimental facility at the Norwegian Centre for Neutron Research (NcNeutron) and the only facility in the Nordic region of this type. NcNeutron is part of the national infrastructure of research under the auspices of the Research Council of Norway, and SINTEF, the University of Stavanger, the University of Oslo and NTNU are all participants. IFE hosts NcNeutron and is a national resource centre for neutrons and fission. We are also an international partner for R&D projects in this field.

Nuclear research activities in Halden

IFE has comprehensive nuclear research activities in Halden in connection with the reactor and through the Halden Reactor Project, which is an international research collaboration on nuclear safety under the auspices of the OECD Nuclear Energy Agency (OECD/NEA).

Twenty countries and more than 100 organisations currently participate in the Halden Reactor Project, which was established in 1958 and is the oldest and largest project in OECD/NEA's portfolio. The OECD/NEA has emphasised the importance of the Halden Reactor Project for global nuclear safety.

The Halden Reactor has been the test facility for the Halden Reactor Project in the field of reactor fuel and reactor materials. Bilaterally commissioned research has also been carried out. The reactor has been in operation since 1959 and was permanently closed down in June 2018.

The sector has highly developed mechanical workshops and machines for electron beam welding that in addition to supplying the sector's own projects are also used in assignments for the petroleum sector and other industries.
In addition, the sector has the broad expertise needed to handle Norwegian nuclear waste in a safe and effective manner. This expertise also comes into play in the phasing out and decommissioning of nuclear facilities.

Highlights in 2018

On 27 June 2018, IFE's Board decided to close down the Halden Reactor. The phasing out of the reactor and the handling of atomic waste will take several decades, and IFE's nuclear expertise will be crucial for cost-effective decommissioning. In the future, IFE will focus on research and activities that do not depend on the reactor.

The decision to permanently close operations at the Halden Reactor was partly based on comprehensive reports showing that in the long term, there was no market basis for the Halden Reactor. Activities there had operated at a loss for several years due to a fall in revenues, and the state had to contribute substantial extraordinary funding over the last year.

The reactor was shut down in March 2018 when a faulty safety valve was discovered during a routine maintenance inspection. In addition, IFE had identified a need for comprehensive investments in the necessary upgrading of safety systems at the reactor in order to start up again.

The planning work involved in the switch from operations to pre-decommissioning and subsequent decommissioning of the Halden Reactor began after the decision was made to close the reactor. IFE has held detailed discussions with the Norwegian Nuclear Decommissioning Authority (NND) with the aim of clarifying how best to organise the distribution of responsibilities and tasks in the interface between them.

IFE worked throughout the summer and autumn to put in place a revised fuel and materials programme at the Halden Reactor Project for the current period (2018–2020). This entailed adjustments and adaptations that were presented at the extraordinary meeting of the Halden Reactor Project's international board in Halden from 11 to 12 September. The international board held its 100th meeting in Paris from 6 to 7 December. Following a year of great changes and considerable uncertainty, it was gratifying that the Board formally approved the revised budget for the Halden Reactor Project for the 2018–2020 period, the revised Fuel and Materials Programme for the period 2018–2020 and the MTO programme for 2019. The budget for the three-year period has now been revised to NOK 371 million (original budget NOK 443 million). The Halden Reactor Project's budget for 2019 will be approximately NOK 116 million, distributed 50/50 between Fuel and Materials, and MTO.

International support for the Halden Reactor Project was also clearly in evidence at the board meeting for the project (Halden Board) in Paris

Photo: Mona L. Ramstad

in December, where the participating countries supported the revised budgets. Through the Halden Reactor Project, the IFE has good contact with the market's most important stakeholders – authorities, power producers, supplier industries and research institutions – and the IFE is known in the market as a reliable supplier of safety data.

On 20 December, IFE's licence to own and operate the nuclear facility at Kjeller and the fuel instrumentation workshop at Os Allé, Halden was renewed for the period 1 January 2019 to 31 December 2028. In recent years, IFE has carried out a comprehensive, long-term control programme and review of the reactor. In January 2019, corrosion was found on several components that are important for its safety. IFE and external experts have analysed the findings and the scope of the necessary repair work. The conclusion was that the repair would require a lengthy shutdown of the reactor and entail costs in excess of IFE's financial capabilities.

Based on an overall assessment, IFE's Board decided on 25 April 2019 not to restart the JEEP II reactor. IFE has started the work to prepare for the decommissioning of the Kjeller reactor.

Good cooperation with the Norwegian Nuclear Decommissioning Authority

In 2018, the government established the Norwegian Nuclear Decommissioning Authority (NND), a public sector agency under the Ministry of Trade, Industry and Fisheries, which is responsible for disposal solutions for Norwegian nuclear waste and the decommissioning of nuclear facilities in Norway. IFE and NND have worked in close liaison since the start and in 2018 have focused on clarifying the demarcation between IFE and NND in the future decommissioning process. In 2018, NND has carried out a starting-up process where the focus has been on forming the organisation and planning for the eventual takeover of tasks and responsibilities.

Sector

Nuclear Waste Management and Decommissioning

The Nuclear Waste Management and Decommissioning sector was established on 1 January 2017 with a view to addressing the recommendations made in official reports (concept studies, 2015 and 2016) on solutions for Norwegian nuclear waste and future decommissioning of nuclear facilities in Norway. The reports clarified the need to initiate efforts to find final disposal solutions for the historical nuclear waste stored at IFE's nuclear facilities at Halden and Kjeller.

The nuclear waste comprises spent fuel from the operation of IFE's research reactors, the remains of experiments on the handling of spent fuel, and long-lived radioactive waste from hospitals and industry for which there are no final disposal solutions at present. Storage is regarded as just a temporary solution, and a final solution would either be the recycling of waste where possible or depositing it in a satisfactory manner in perpetuity.

The Norwegian government has assumed joint responsibility for clearing up nuclear waste, and the sector's work is governed by the letter of allocation from the Ministry of Trade, Industry and Fisheries. Activities are mainly funded through government grants via the central government budget.

Sector organisation

The sector is divided into three departments and has a programme dealing with activities related to

waste management and the future decommissioning of Norway's nuclear facilities.

The ***Radwaste Department*** receives, handles and stores solid and liquid radioactive waste from IFE's own activities and also from external activities in the trade and industry sector, defence, the public health service and research. IFE's facilities constitute the national centre for these services. The aim of the technical processes at the facility is to reduce the volume of waste so that the amount to be stored is as small as possible. Thereafter, the waste is encapsulated so that it is suitable for long-term storage. The purpose of encapsulation is to prevent the release of radioactive materials into the environment. The department is responsible for the operation of a combined deposit and storage facility for low- and intermediate-level radioactive waste (KLDRA) in a rock cavern in Himdalen in Aurskog-Høland municipality. The Norwegian government, represented by the Norwegian Directorate of Public Construction and Property, is the owner of the Himdalen facility.

The ***Nuclear Technology Department*** is a technical department that shall mainly contribute resources to the Historical Nuclear Waste and Decommissioning Programme. In addition, the department is responsible for facilitating the process of establishing agreements with other sectors for technical assistance in connection with programme tasks.
The ***Project Management Department*** is responsible for developing the necessary methods, systems and tools for carrying out the programme projects. Its future development will depend on the design of the solution for transferring tasks from IFE to the Norwegian Nuclear Decommissioning Authority (NND).

Both the Nuclear Technology Department and the Project Management Department contribute resources and technical expertise to the Historical Nuclear Waste and Decommissioning programme. The sector is thus defined as a matrix organisation.

The ***Historical Nuclear Waste and Decommissioning Programme*** was established to ensure overall follow-up of the main recommendations made in the official reports mentioned above. The overarching recommendations cover all tasks that must be accomplished in order to find short-term and long-term solutions for nuclear waste, and to ensure a good combination of solutions for storage of nuclear waste and decommissioning plans.
The programme consists of a total of nine sub-programmes in addition to programme management. Each sub-programme includes numerous projects that form part of an established programme structure. A dedicated planner has been engaged for the programme. IFE is particularly involved in some programmes, such as the safe storage of spent fuel, final disposal solutions for fuel and the planning of the decommissioning of the nuclear facilities.

Highlights in 2018

In 2018, activities in the Historical Nuclear Waste and Decommissioning Programme have largely focused on developing plans for the solutions needed to secure appropriate storage of spent fuel and facilitate the export of unused fuel that IFE itself will be unable to use. Activities will primarily be linked to acquiring the necessary information about the spent fuel (characterisation). This will be done at a level of detail and a scope not previously experienced at IFE.

New, wide-sweeping requirements from the Norwegian Radiation and Nuclear Safety Authority linked to safety reports from the nuclear facilities will also help to improve the safety at spent nuclear fuel storage facilities. The revision of safety reports from these facilities is a comprehensive task, which IFE has prioritised.

There are plans to establish a new storage facility for spent fuel at Kjeller as a replacement for the historic nuclear waste storage facility (JEEP I rod wells) for fuel from JEEP I. The reactor, which started up in 1951, was Norway's first atomic reactor, and was number six globally. Damp and rust have been detected, and it has been established that the condition of this storage facility has not been satisfactory.

Following the decision to shut down operations at the Halden Reactor, efforts to establish plans for decommissioning nuclear facilities in Norway have intensified.

Transfer of tasks from the sector to the Norwegian Nuclear Waste and Decommissioning Authority
The Norwegian Nuclear Waste and Decommissioning Authority (NND) was established on 1 January 2018 and is planned to be fully operative as from 2021. A prime task for IFE and the Nuclear Waste Management and Decommissioning sector will be to find a way of transferring tasks from the sector to NND whilst simultaneously safeguarding IFE's pool of expertise during the transitional phase.

Photo: Espen Solli

Environment and safety

IFE is subject to a strict body of regulations on safety and emissions. Our safety is closely monitored both nationally and internationally. In the case of emissions, the Norwegian Radiation Protection Authority sets limits for how much radioactive materials we are allowed to discharge to air and water. The emissions licence sets specific emission limits per radio nuclide. In addition, limits are set for the maximum dose of radiation to which individuals in the most vulnerable population groups can be exposed. The limits are very low. However, our emissions are far lower than the maximum values. In 2018, radioactive emissions to air and water from the Kjeller facilities amounted to 1.52 per cent and 5.1 per cent of the applicable dose limit, while for Halden the emissions to air and water were 1.1 and 0.05 per cent of the annual dose limit.

Ongoing surveillance of radioactivity

The Health and Safety Department at Kjeller and the Radiation Protection Department in Halden have wide-ranging expertise in radiation protection, radioecology and radioactive waste, and play a key role in Norway's nuclear emergency preparedness. We conduct research and provide assistance for industry, the public health service, the authorities and research institutes using expertise developed at IFE. IFE has laboratories for measuring radioactivity in a variety of sample types, for dosimetry and calibration of radiation protection instruments in addition to its own electronics laboratory.

The responsibility of the Radiation Protection Department is to ensure that all use of radioactive sources and materials is in accordance with national laws, regulations and guidelines. Moreover, the Department evaluates and follows up the recommendations of international organisations. The aim is to limit and reduce any radiation doses for employees at work and check that emissions during normal operations do not exceed the emission limits. The Radiation Protection Department plays an important role in IFE's emergency preparedness should unforeseen events occur.

IFE's environmental monitoring ensures that we have a full overview of our total footprint. This partly takes place through the environmental monitoring programmes at Kjeller and in Halden. Every year, IFE issues a report on the environment with a detailed environmental audit and a description of IFE's work with health, safety and the environment.

Focus on safety culture

IFE's Board and management take a targeted approach to improving our safety and safety culture. We set high standards in terms of safety and the safety culture. We will continually strive to become better, to adopt best practice, and to gain experience and knowledge from international, leading edge research communities.

In 2018, a group of experts from the International Atomic Energy Agency (IAEA) conducted an Independent Safety Culture Assessment (ISCA) of IFE. The IAEA's main conclusion was that IFE's local cultures are strong, its safety culture is

continually improved and its employees assume responsibility for safety. Meanwhile, the IAEA also pointed to areas that could benefit from strengthening and improvement, such as systematic management development, standardised training, experience exchange across the organisation and internationally, organisational learning, and a clearer management and quality system. IFE has used the findings in the ISCA, and the IAEA's recommendations in the efforts to reinforce the safety culture in 2018.

Furthermore, IFE has strengthened its work on internal surveys and causal analyses to monitor non-conformance. This work is being further reinforced in 2019 with the input of new resources.

In 2018, IFE has prepared a new risk and vulnerability analysis. This will entail a considerable increase in measures to improve physical safety and information security in the years ahead. The reinforcement of physical safety at IFE has been in continual focus in 2018.

Focus on privacy protection

In 2018, IFE established a project group that commenced work on mapping and documenting the General Data Protection Regulation (GDPR) at IFE, to ensure that this complies with the new EU regulation. IFE decided to create a position as a privacy policy advisor.

IFE's EU drive

The positive trend from 2017 has continued, and IFE has increased its efforts vis-a-vis the EU's research programmes. This has given excellent results: IFE had the ambitious goal for 2018 of participating in 32 EU research applications.

In total, IFE submitted 37 EU research applications in 2018 – an increase of over 300 per cent compared with 2017.

The average rate of success in the EU's Horizon 2020 research programme when the application fulfils all the formal requirements is 14 per cent. In 2018, IFE had a success rate of 30 per cent. A total of eleven projects were granted funding. Altogether, 79 per cent of the applications satisfied the threshold requirements. In other words, the applications that IFE submits or participates in maintain an extremely high quality and we have many excellent, robust partners.

The thematic areas in which IFE has been most successful so far include environmentally friendly industrial processes, neutron materials characterisation, solar energy and risk analysis. Going forward, IFE will focus more on improving its positioning in battery technology, CCS, cybersecurity, artificial intelligence and cancer medicine.

IFE has defined four overarching strategic priority areas: renewable energy, digitalisation, health and nuclear technology. The areas strongly reflect the EU Commission's priorities and IFE is well positioned for further growth and success in the European research programmes.

The list of partners in these projects comprises more than 190, since EU projects have roughly twenty partners on average.

For Horizon 2020, we have identified many calls for proposal that are relevant for IFE's strategic research initiatives. They represent the three main pillars of Horizon 2020 (Excellent Science, Industrial Leadership, and Societal Challenges).

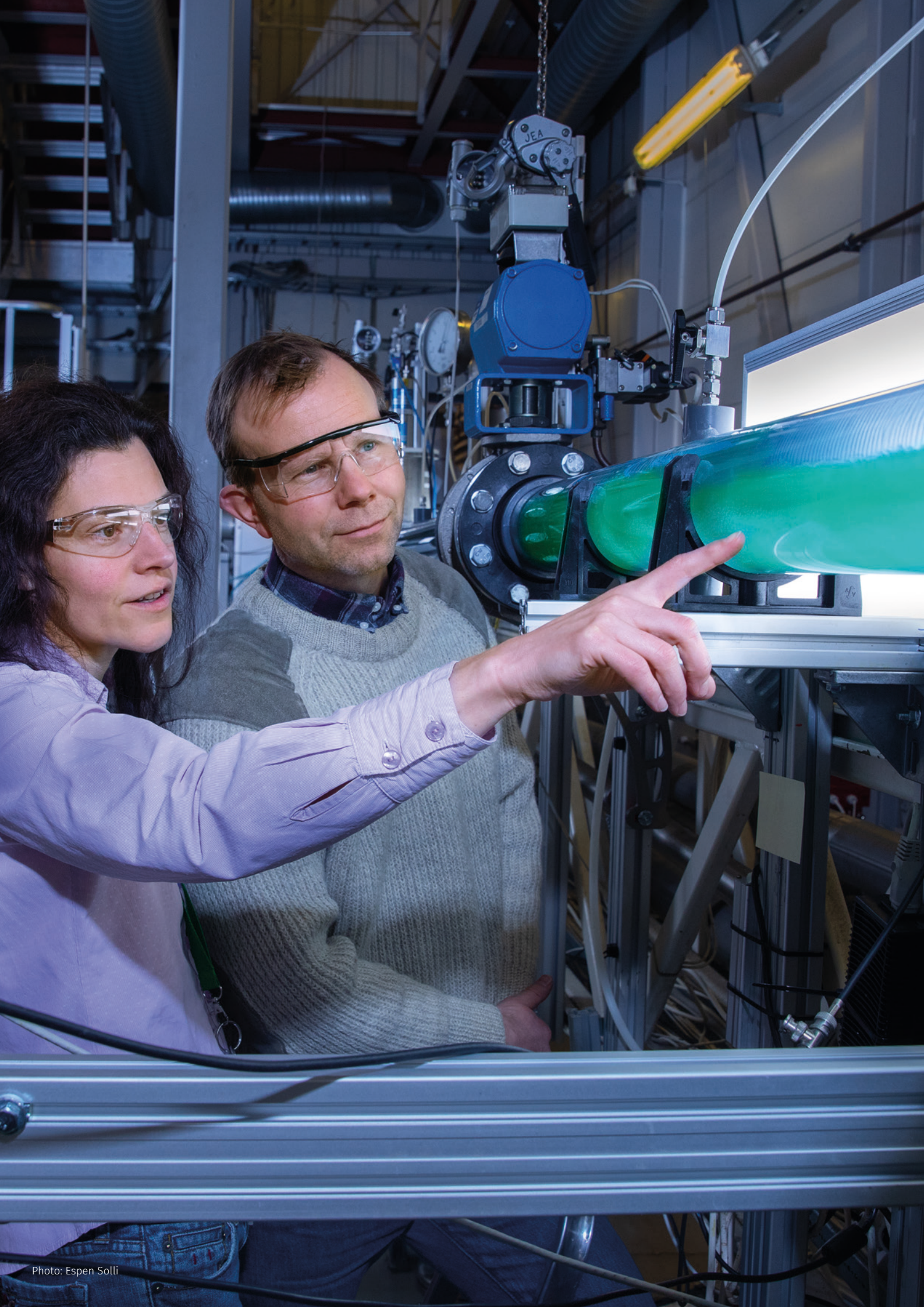

Photo: Espen Solli

Innovation and commercialisation

IFE has a long tradition of commercialising ideas from research and has garnered a range of experiences. Some commercialisation initiatives have become successful companies, including Scandpower, SPT Group, Resman, Restrack, Visavi, APT and Zeg Power. In other cases, such as the multi-phase technology project OLGA, licensing has generated good revenues for many years.

IFE is an active partner in the innovations environment at Kjeller, which probably represents Norway's most complete innovations system alongside the NTNU and SINTEF environments in Trondheim. IFE holds a ten per cent ownership stake in Kjeller Innovasjon AS, which is the commercialisation incubator (Technology Transfer Office) for the institutes at Kjeller. Akershus county municipality and Siva are also key owners. The business developers at Kjeller Innovasjon assist IFE and IFE Invest to develop ideas, establish and develop companies, and apply for funding from a range of instruments.

In 2008, IFE Venture AS was established as a wholly-owned subsidiary with the aim of increasing the commercialisation of IFE's research. The company changed its name to IFE Invest in 2017 and since autumn of that year, the former chief financial officer of IFE, Jørgen Lundberg, has held a full-time position in the company. IFE Invest AS establishes and develops companies, and as an active owner provides support for daily management, further market development, upscaling and capital injections. Investment capital totals approximately NOK 30 million and there are currently six companies in the portfolio. In addition, IFE Invest administers IFE's assets in the NIK III fund and IFEs Boligselskap. IFE has had access to a certain amount of early-phase capital via IFE Invest AS, Akershus Technology Fund and Norsk Innovasjonskapital (NIK).

Income statement

Parent company *Figures in NOK thousand*				Group *Figures in NOK thousand*	
2018	**2017**	**Income statement as at 31 December 2018**	**Note**	**2017**	**2018**
655 481	710 653	Contract revenues	11	735 427	655 910
351 651	137 544	Government subsidies	10	137 544	351 651
65 358	91 782	Contributions from international partners at Halden		91 782	65 358
2 093	2 736	Other operating income		3 445	2 337
1 074 583	**942 715**	**Total operating revenues**		**968 198**	**1 075 256**
575 914	554 070	Pensions	12	569 272	577 345
70 350	70 399	Cost of sales		71 821	70 350
365 543	318 956	Other operating expenses	12, 13	327 972	364 512
25 539	23 433	Depreciation, fixed and intangible assets	2	24 036	25 539
15 566	0	Write-down of fixed assets	2	0	15 566
1 052 911	**966 858**	**Total operating expenses**		**933 101**	**1 053 311**
21 672	**-24 143**	**Operating profit/loss**		**-24 903**	**21 945**
1 675	1 644	Financial income	14	3 038	2 080
1 825	3 145	Financial expenses	15	7 094	11 073
-150	**-1 501**	**Net financial items**		**-4 056**	**-8 993**
21 522	**-25 644**	**Profit before tax**		**-28 959**	**12 952**
0	0	Tax	9	-642	2 454
21 522	**-25 644**	**Net profit/loss for the year**	**17**	**-28 317**	**10 498**
		Minority's share of profit		148	
		Majority's share of profit		-28 464	
		Allocation of net profit for the year			
21 522	-25 644	Other equity/uncovered losses	17		7

Report of the Board of Directors

The Institute for Energy Technology was established in 1953. The foundation's objective is to work on a not-for-profit basis for the public good by conducting research and development in the field of energy and other areas where the foundation's expertise is of particular relevance. The Annual Report provides a consolidated income statement for the IFE foundation and the group. The group comprises IFE, IFE Invest and IFEs Boligselskap AS. IFE is a research institute for engineering and industrial development and receives core funding from the Research Council of Norway.

IFE is a significant energy research institute and Norway's largest centre of excellence within nuclear technology. The institute has a total turnover of around NOK 1 billion and a staff of 600. The nuclear research activities, Radiopharmacy and Research and Development each account for approximately 30 per cent. The foundation's main offices are at Kjeller in the municipality of Skedsmo. The business is run from our premises at Kjeller and in Halden.

The institute's three business areas are: i) research on energy, digital systems, health and nuclear technology; ii) radiopharmaceuticals, in our roles as development partner, producer and distributor; and iii) nuclear technology, involving extensive infrastructure tailored for nuclear activity.

The JEEP II research reactor at Kjeller has been operating since 1967. The reactor is an important part of the national research infrastructure where IFE, in partnership with universities and research institutes at home and abroad, conducts research into physics, materials technology, radiopharmaceuticals, energy storage, CO2 management and hydrogen technology.

In 2018, it was decided to close the Halden Reactor permanently. Since 1958, the reactor has hosted the Halden Reactor Project, which is an international research programme run by OECD/NEA (Nuclear Energy Agency). Parts of the Halden Reactor Project will continue, despite the closing down of the reactor. Estimates suggest that it will take approximately 20 years to complete the phasing out and removal of the Halden Reactor.

The Norwegian Nuclear Decommissioning Authority (NND) has been set up by the Norwegian government to be in charge of the demolition of the Halden Reactor and other nuclear facilities. Considerable efforts are being made to plan and prepare for the decommissioning, and to arrange for the transfer of facilities to NND.

Main activities in 2018

In 2018, IFE's finances stabilised after several years of weak results. Government subsidies received for the phasing out of the Halden Reactor balanced out the loss of income that followed from stopping the reactor. Moreover, IFE has increased the foundation's income from non-nuclear energy research projects, introduced restructuring and cost-reducing measures throughout the business and implemented strict financial control.

Radiopharmaceuticals has seen formidable growth in turnover and staffing levels in recent years. The profit generated by this activity has been very important to IFE's overall financial situation and has covered a considerable part of the losses incurred by the nuclear activities over several years. Radiopharmaceuticals continued to deliver good results in 2018, although revenues from the production of Xofigo are falling. From our premises at Kjeller, IFE works in close partnership with Bayer on contract production of the cancer drug Xofigo for the global market. IFE also works with Bayer and other companies on numerous innovations, and we are currently preparing to expand our radiopharmaceutical production capacity.

There are promising market developments with respect to renewable energy, energy systems and environmental analysis, and these areas are expected to see increased turnovers in the time ahead. The digital systems sector has succeeded in securing new contracts in 2018 and the outlook is good for 2019 and the years ahead.

In June 2018, the Board of Directors decided against restarting the Halden Reactor, which resulted in higher levels of activity relating to the clear-up of historical nuclear waste. Government subsidies therefore make up a larger proportion of our income compared to previous years. The closing down of the Halden Reactor led to the Halden Reactor Project being renegotiated in 2018, and payments from membership organisations fell by NOK 13 million. IFE's research sector has in recent years been focusing its efforts on increasing the number of applications submitted to national and EU programmes, and this work has paid off. Incomes from EU projects amount to approximately NOK 21 million, and this has increased in the past year.

New parameters

A new licensing regime came into force with the award of a licence for Kjeller for the period from 2019 until the end of December 2028. Provisions that were previously international recommendations have now been formalised as legal requirements. The new licensing conditions introduce a number of new and specific obligations relating to operation, maintenance and safety.

Photo: Espen Solli

As a part of the licence extension application process, IFE decided to conduct a thorough ageing control of the JEEP II Reactor with respect to several safety-critical components. Investigations commenced in December 2018. In January 2019, significant corrosion was detected on components that are essential to operation and safety. It may therefore be impossible to start the reactor up again in 2019.

This situation will involve a loss of income of NOK 45 million in 2019, a prospect which has given rise to uncertainty about the reactor's future. IFE is in talks with the Norwegian Ministry of Trade, Industry and Fisheries about the situation.

The new licensing regime also introduces stricter operating and safety requirements at IFE's other nuclear facilities. IFE has therefore commenced a review associated with the infrastructure of all the foundation's nuclear facilities. This has identified a considerable need for increased resources to enable IFE to satisfy the new licensing regime in respect of maintenance, a stronger safety organisation, and the training required to maintain our level of expertise when allowing for natural wastage.

Great potential in renewable energy

There is considerable growth in the demand for IFE's research within renewable energy and energy systems, and IFE is increasing staffing levels within these areas. IFE hosts two Centres for Environment-friendly Energy Research (FME), one of which is MoZEES – Mobility Zero Emission Energy Systems, which involves 40 partners from R&D, industry and public sector agencies. The partners are working together to develop zero emission solutions for road, rail and sea. The other centre is SUSOLTECH - Research Centre for Sustainable Solar Cell Technology, whose objective is to develop the world's most environmentally friendly and effective solar cells, working in close liaison with the Norwegian solar industry.

Both FME centres enjoy a high level of activity and play an important role in the development and positioning of Norwegian industry and research. At MoZEES, nine PhD students have been directly involved with activities in 2018, and a network has been established to provide support for young researchers.

IFE benefited considerably from the Research Council's ENERGIX programme and is now the lead partner in a total of eight new projects. This reinforces IFE's position as a leading research institute within renewable energy and energy systems. We have been awarded three new projects from the MAROFF programme (Maritime Activities and Offshore Operations), one from PETROMAKS2, and two BIA projects (user-controlled innovations arena). In 2018, IFE increased its number of applications for EU funding, resulting in a 35 per cent success rate for applications for Horizon 2020 funding.

IFE has traditionally worked closely with Norwegian industry. This partnership has been further strengthened in 2018 through long-standing relationships with manufacturing companies, some of them start-ups, others well-established, like Elkem, Equinor and Hydro

Strategic investment in health research and digitalisation

In 2017, IFE strengthened its position within health research by being awarded BIA funds from the Research Council. One project involves the production of biological drugs and radiopharmaceuticals in Norway. A second project involves the development of an innovative production technology for radio nuclides that is cheaper and more environmentally friendly than today's technology. Another innovative project is run in partnership with Oslo University Hospital Rikshospitalet. With funding made available from the South-Eastern Norway Regional Health Authority, this project applies research from flow technology in the petroleum industry to blood circulation in the human body. In 2018, IFE has strengthened its partnership with private and public health organisations in Eastern Norway through innovative projects.

Renewable energy, digitalisation and health are IFE's strategic areas of investment for the years ahead, and they match the need to develop new, sustainable solutions to global social challenges within the areas of energy, health, transport and infrastructure.

IFE has set up a number of new businesses through the years, offering jobs based on research. In 2018, we further strengthened our investment in innovation and commercialisation, and the institute has seen several successful commercialisations this year.

IFE's contribution to the European Spallation Source (ESS)

IFE's expertise and activities are important to the international partnership which is constructing the world's most powerful neutron source, the 'European Spallation Source' (ESS) in Lund, Sweden. The national research infrastructure NcNeutron (Norwegian Centre for Neutron Research) is currently being built at the JEEP II Reactor at Kjeller. This will be fully operational in 2020 with seven state-of the-art instruments. According to plan, ESS will be ready for the first experiments at the end of 2023 and will be fully developed by 2026 at the earliest. IFE and NcNeutron will be important for the future Norwegian use of ESS, both as a Norwegian resource centre within neutron-based materials research and to ensure that Norwegian research communities and industry will be able to utilise ESS.

Thanks to funding from the Research Council, the Kjeller Reactor has been used for testing and optimisation of ESS equipment. IFE contributes significantly to the development of two of the fifteen instruments planned for ESS, working with other European research institutes in doing so. Furthermore, IFE carries the main responsibility for the design and installation of the ESS control room and several of its important control systems.

Scientific publishing

The production of scientific articles has increased considerably compared to 2017 (figures in brackets). In 2018, a total of 142 (107) scientific articles were published in international journals and other publications approved for the Norwegian Science Index. The Board considers it important that IFE maintains its ambition to publish at a high international level.

Health, safety and the environment

In 2018, IFE reported to the Norwegian Radiation and Nuclear Safety Authority (DSA) fifteen incidents arising from the institute's activities that could potentially have impacted on the environment, health or safety. The situations were handled in a way that ensured any such impact was avoided.

IFE has established a new procedure for reporting incidents to the DSA. This has meant that more cases are reported, including issues that are of no consequence to the environment or to the health and safety of the population or our staff.

IFE's Board and management have been working systematically to enhance safety and the safety culture. These efforts are continuous and must be constantly improved. IFE's activities put great demands on safety and the safety culture. We will always seek to improve and to conform with best practice, and we will seek to learn from the experience and knowledge found in leading international circles.

In 2018, a group of experts from the International Atomic Energy Agency (IAEA) conducted an Independent Safety Culture Assessment (ISCA) of IFE. The IAEA's main conclusion was that IFE's local cultures are strong, its safety culture is continually improving and its employees assume responsibility for safety. Meanwhile, the IAEA also pointed to areas that could benefit from strengthening and improvement, such as systematic management development, standardised training, experience exchange across the organisation and internationally, organisational learning, and a clearer management and quality system.

IFE's work to strengthen the foundation's safety culture in 2018 has made positive use of the ISCA results and implemented the IAEA's recommendations.

Furthermore, IFE has strengthened its efforts to conduct internal investigations and causal analyses in order to follow up non-conformance and to implement systematic learning and improvement. This work will be further bolstered in 2019 thanks to additional resources being made available.

In 2016, IFE's safety classification was changed, and in June 2017 we were informed of the new content. IFE received a new design basis document (DBT) from the Norwegian Radiation and Nuclear Safety Authority in January 2018 and has worked through the year on conducting a new risk and vulnerability analysis. This will involve a considerable increase in the number of measures introduced to improve physical safety and information security in the years ahead. We have been working continuously to strengthen physical safety at IFE.

IFE is subject to strict safety and emissions regulations, and we are closely monitored by national and international agencies. The Norwegian Radiation and Nuclear Safety Authority determines the allowable limit for radioactive emissions to air and water. The limits are very low, and our emissions are far lower than the maximum values.

IFE monitors the working environment by means of regular HSE surveys and reports. Sick leave in 2018 stood at 4%, up from 3.4% in 2017. A total of ten personal injuries were recorded in 2018. No one was exposed to a radiation dose rate that exceeded the occupational exposure limit of 20 mSv/year. One serious accident or near miss was reported in 2018.

IFE follows up sick leave in accordance with the agreement on inclusive working life (IA agreement). Extensive working environment surveys are conducted every two years, and the surveys are systematically followed up by HR assistance being provided to any area where a particular need has been identified. The next working environment survey will be carried out in the spring of 2019. In 2018, IFE enhanced its efforts within organisational development and change management by employing a supervisor specifically to provide assistance during the implementation of organisational processes and to provide management development input.

Personnel

IFE works actively, methodically and systematically to promote equality, safeguard equal opportunities and rights, and prevent discrimination based on gender, ethnicity, religion and faith. There must be no discrimination due to disability and the institute works actively and systematically to design and adapt the physical environment to ensure that our premises are accessible to as many as possible.

IFE has been an IA company since 2010 and work areas and tasks are adapted to suit individual employees. In 2018, IFE employed permanent and temporary staff from 38 different nations. The resulting diversity enriches the organisation both professionally and socially. The mix of nationalities makes it easier for new staff with less experience of Norwegian culture to adapt to working life in Norway. IFE has found that this is a competitive advantage when it comes to recruitment.

In 2018, IFE retained its 11th place on the list of Norway's most desirable employers for engineering students. The Career Barometer provides a ranking of the most popular employers among various student groups, based on an annual student survey.

As of 31 December 2018, IFE's permanent staff included a total of 609 employees, compared with 594 in 2017, of whom 38 per cent are women. Of these, 226 (219) have a higher education, and 37 per cent of these are women. A total of 105 permanent and temporary members of staff hold a PhD, which is a slight decrease from 108 in 2017, and 30 of these are women. Six out of thirteen members of the current management group are women, compared with four in 2017. The Board attaches great importance to IFE's prioritisation of equal opportunities work throughout the organisation.

In June 2018, the Board of Directors decided to close down the operation of the Halden Reactor. The decision was preceded by a demanding process that involved great uncertainty for staff. IFE's management held a series of information meetings and discussions with union representatives, as well as general staff meetings, throughout the first half of 2018. The management and union representatives had differing opinions as to whether the discussion process was sufficiently robust to meet the requirements of the Basic Collective Agreement. All in all, the Board considers 2018 to be a year of good industrial relations with the unions.

Government subsidies received following the decision to phase out the Halden Reactor have led to greater financial stability for the foundation, and the closing down of operations has not required any cuts to staffing levels. Only three people working at the Halden Reactor have resigned, and this has not had an impact on safety. IFE's Board feels it is essential that IFE retains predictable financial parameters in order to keep the nuclear expertise available at IFE in the years ahead as it is important for the safe and effective decommissioning of nuclear facilities and management of nuclear waste. IFE is working systematically to establish what expertise Norway needs in the years ahead with respect to decommissioning and nuclear waste.

This work will form a basis for future adjustments and the retraining of IFE's staff, which will represent an important challenge as from 2019.

IFE in the media and in society

IFE's nuclear research activities put us in a special position in Norway. Transparency and openness about our work are important to IFE's reputation and impact significantly on the role we play in society. In 2018, we enhanced our efforts relating to communication and public relations. We are more active in the media and we use social media to disseminate information about and explain our research and nuclear activities. We write feature articles and make other contributions to national and local newspapers, assist the media with expertise within our fields of research and provide speakers for national and international conferences.

In 2018, IFE has further strengthened in-house communications in a number of ways, for instance by holding regular and frequent staff meetings at Halden and at Kjeller.

External environment

Since IFE's formation in 1948, the institute has been operating under licences and permissions granted by the Norwegian government as represented by the DSA, the Norwegian Environment Agency and other bodies that regulate our activities and monitor compliance with current rules and guidelines for the management and storage of Norway's nuclear waste. Because Norway was one of the first countries to have a nuclear reactor, we were an early producer of nuclear waste. In total, Norway has produced almost 17 tonnes of spent reactor fuel. At the start of 2018, a further four tonnes of other radioactive waste was stored at IFE's premises. This is waste that cannot be deposited in the National Combined Disposal and Storage Facility (KLDRA) at Himdalen in Aurskog-Høland municipality.

The rules for managing nuclear waste have changed since the reactor was commissioned in the early 1950s. The requirement for detailed specifications of the stored waste was far less stringent at the time. The storage facilities that were constructed in Halden and at Kjeller were never intended to house nuclear waste over many decades.

For many years, IFE has been working to persuade the government to assume shared responsibility for Norway's nuclear waste and to contribute to the clear-up and permanent storage of the waste. Over the years, the government has set up committees with a remit to investigate intermediate storage of spent fuel. In July 2016, the Minister of Trade and Industry announced that the government accepts shared responsibility for funding the future decommissioning of Norwegian nuclear facilities and for the storage of Norwegian radioactive waste. In 2018, the Norwegian Nuclear Decommissioning Authority (NND) was set up, and the organisation is currently being built. NND and IFE collaborate extensively to coordinate and safeguard joint prioritisation of activities, and to prepare for the transfer of nuclear facilities, tasks and expertise from IFE to NND. Until NND has been awarded a licence and has acquired sufficient expertise, most of the work involved with the decommissioning

of nuclear waste must be carried out by IFE. This will remain the situation for many years and will require predictable government funding of IFE's work to maintain progress. IFE's cost estimate for the decommissioning and clear-up of nuclear waste amounts to NOK 400–600 million in the years ahead.

There has been good progress made in the work to ensure safe management of nuclear waste and planning the decommissioning of nuclear facilities, but the work is still in an early phase. In many respects, the government and IFE will make decisions as the situation develops, and this requires flexibility, pragmatism, great resilience and an extreme long-term perspective from all the parties involved.

Experience from 2018 shows that preparing for decommissioning and the management of nuclear waste is far more complicated and resource intensive than the estimates on which the government's impact and quality assurance reports were based in 2015–2016. The challenge involves the phasing out of 70-year old national nuclear facilities with four reactors and a series of associated nuclear plants.

IFE has received a growing number of instructions from the Norwegian Radiation and Nuclear Safety Authority (DSA) with respect to the safe management of nuclear waste, including new requirements relating to safety documentation for the management of spent fuel and the building of new storage facilities. The result is that increasing amounts of time and money are spent on analysing and responding to the instructions. Instructions issued by DSA and the Norwegian National Security Authority (NSM) lead to comprehensive safety measures that require investment and push up operating costs due to a growing number of security staff and the introduction of measures relating to physical and logical safety.

In 2018, IFE was awarded an extraordinary government subsidy of NOK 50 million towards the operation of the Halden Reactor. This was a contribution towards the retention of critical reactor competence for the forthcoming clear-up operations at the nuclear facilities. In the Revised National Budget for 2018, IFE was awarded a further subsidy of NOK 75 million. This was to ensure that staff were retained in compliance with the licensing conditions, to maintain safety and hold on to nuclear expertise, despite the winding up of operations and the loss of revenue. We believe that the government wants to liaise closely with IFE on the way ahead and is committed to retaining IFE's nuclear expertise for the management of nuclear waste and the future decommissioning of the reactors.

The annual financial statements

The group's consolidated turnover from the IFE Foundation amounted to NOK 1075 million (NOK 968 million in 2017). The Halden Reactor was shut down in 2018, which resulted in reduced incomes from foreign participants in the Halden Reactor Project to the amount of NOK 26 million in 2018. The loss of income has been offset by increased government subsidies used to cover the Halden Reactor's operating losses, and to pay for the nuclear waste clear-up operation as well as preparatory decommissioning work. The foundation's

operating revenues stem from research projects associated with our R&D activities. These are projects which are part funded by the Research Council, EU and other industry partners. Additionally, a considerable share of the foundation's income is generated from the production and wholesale distribution of radiopharmaceuticals (NOK 326 million).

The group accounts show a profit of NOK 10.5 million, while the foundation's profit amounts to NOK 21.5 million. The difference is largely due to the loss made by IFE Invest (NOK 4 million) and the sale of a shareholding in Restrack AS. Restrack AS was a subsidiary of IFE Invest and was consolidated in the foundation's group accounts for 2017.

The foundation's year-end result has improved considerably compared with 2017. This is largely thanks to government subsidies that have allowed us to reduce the losses made by our nuclear research activities. The bulk of the profit was generated by the radiopharmaceutical activities.

As of 31 December 2018, the group's consolidated equity amounted to NOK 344 million (NOK 334 million in 2017), while the foundation's equity amounted to NOK 292 million (NOK 271 million in 2017). The equity ratio is 50 per cent, which is considered satisfactory.

The cash-flow statement shows a positive difference between profit before tax and net cash flow from operations of NOK 73.6 million for the foundation and NOK 82.1 million for the group. The positive difference is largely due to more of the foundation's debtors have settled their accounts early, and because of the net income effect of write-downs in connection with the phasing out of the Halden Reactor. The amount of advance payments from debtors is expected to fall so that the effect will be reversed in 2019. The group's consolidated cash balance has been strengthened by NOK 89 million while the foundation's cash balance has been improved by NOK 74 million. The positive cash balance has been achieved thanks to improved net incomes and a higher volume of early settlements of accounts receivable.

Financial risks

Liquidity risk

In 2018, the foundation's cash-flow development was positive. Bank deposits accounted for NOK 93 million at the end of 2018, which is NOK 73 million higher than at the end of 2017. For the foundation's liquidity risk to be acceptable, the available cash balance should be in the range of NOK 100 million in order to cover current liabilities. The foundation has a cash pool agreement with IFE Invest AS and IFEs Boligselskap AS. This provides flexibility short-term liquidity fluctuations. The foundation has agreed with its bank that an overdraft facility will be made available as required.

Market risk

The market risk to which the group and the foundation are exposed is principally associated with currency, partly from income in foreign currencies and partly from costs in foreign currencies.

Measures to reduce exposure to currency risks are implemented to any large individual transaction, but there are no ongoing hedging transactions because the risk is considered to be low.

Credit risk
Both the group and the foundation are exposed to credit risks associated with accounts receivable and lending. The group has made provisions for bad debts to the sum of NOK 22.0 million, of which the corresponding sum in the foundation is NOK 11 million. There is also a potential credit risk associated with advance payment to suppliers, but such transactions are subject to the provision of a supplier's performance bond.

Outlook

Safety and security are areas that will need to be bolstered in the time ahead due to stricter requirements imposed by the authorities. IFE was awarded a renewal of the foundation's licence to operate the nuclear facilities at Kjeller for a ten-year period commencing 1 January 2019. The Norwegian Radiation and Nuclear Safety Authority has tightened the licensing conditions in keeping with international regulatory developments and practice. It is positive that Norway is now aligned with international practice within nuclear safety and security.

Given the alterations to the foundation's parameters and licensing conditions, combined with a need for investment in order to maintain and upgrade our nuclear facilities in compliance with new requirements, IFE is uncertain about the future of reactor operations in Norway. The Norwegian Ministry of Trade, Industry and Fisheries has commissioned reports on the financial aspects of the reactor at Kjeller, as well as a report on the reactor's usefulness to research. These reports will be completed by the summer of 2019. In addition, IFE has commenced an analysis of alternative research infrastructures with the aim of maintaining and further developing the research activities at IFE and nationally, which currently depend on the JEEP II Reactor as a source of neutrons.

The foundation's financial situation stabilised in the course of 2018. IFE is looking at considerable investment in safety and security in the years ahead due to of our new safety classification. Moreover, we have uncovered an investment and maintenance backlog in large parts of our infrastructure and in many of our buildings and laboratories. IFE is working systematically to increase revenues and reduce costs.

The Board is keen to improve the profitability of IFE's research activities. In 2018, we have further developed our commercial culture through increased market activity and clearer priorities. This is paying off.

The outlook is good for the institute's R&D and radiopharmaceutical activities. It is important that the potential of these focus areas is fulfilled in the time ahead as our task here is to deliver new and sustainable solutions that address societal challenges.

IFE is a desirable partner to Norwegian industry, international industrial collaborators like Bayer, and R&D groups at home and abroad. IFE has been conducting research for a better future since 1948 and our research is highly relevant to society and industry.

IFE's Board of Directors has commissioned an analysis of the foundation's corporate structure. The objective is to facilitate a transfer of our nuclear activities to the state, and to develop the potential of R&D and radiopharmaceuticals. In the course of 2019, the Board of Directors will consider whether a corporate group structure is advantageous for the institute.

IFE was in a difficult financial situation at the start of 2019, due to the closing down of the Halden Reactor and the resulting loss of revenues. The situation was exacerbated when corrosion was detected in the JEEP II Reactor, which meant it could not be re-started as planned in February 2019. The estimated loss incurred by our nuclear research activities amounts to NOK 126 million for 2019. IFE has taken action to reduce costs but is dependent on supplementary government subsidies for the nuclear research activities in 2019. The radiopharmaceutical activity has a sound economy and prospects are good for 2019. R&D is adjusting in order to achieve robust net incomes in the time ahead. The Board of Directors confirms that the criteria for continued operation are present, subject to government subsidies being forthcoming for the nuclear research activities. The Board has prepared the annual accounts for 2018 on a going concern basis.

Kjeller 25 April 2019

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President

Olav Fjell
Chairman of the Board

Anne Marit Harris
Deputy Chairman

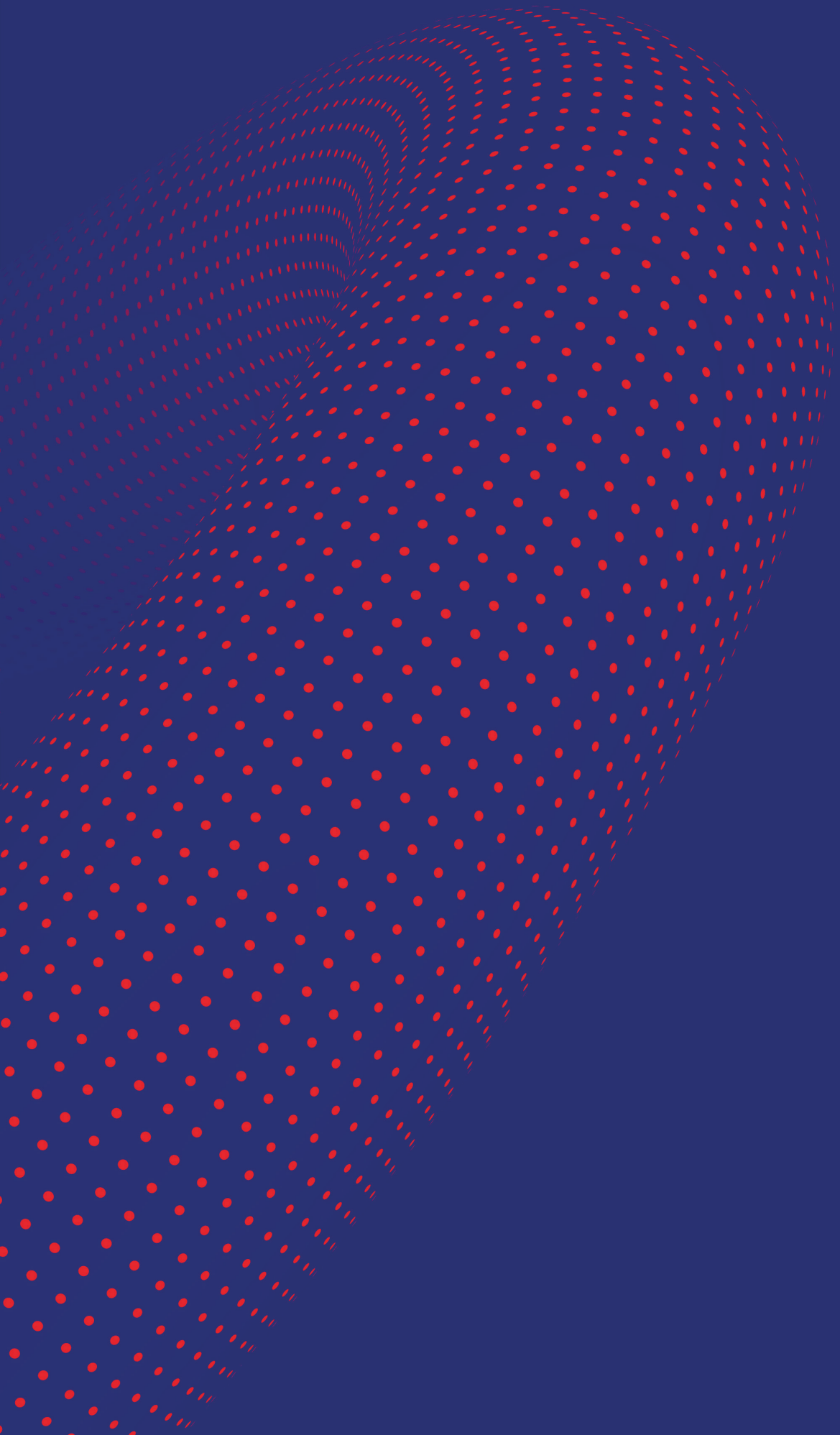
Jo Døhl
Board Member

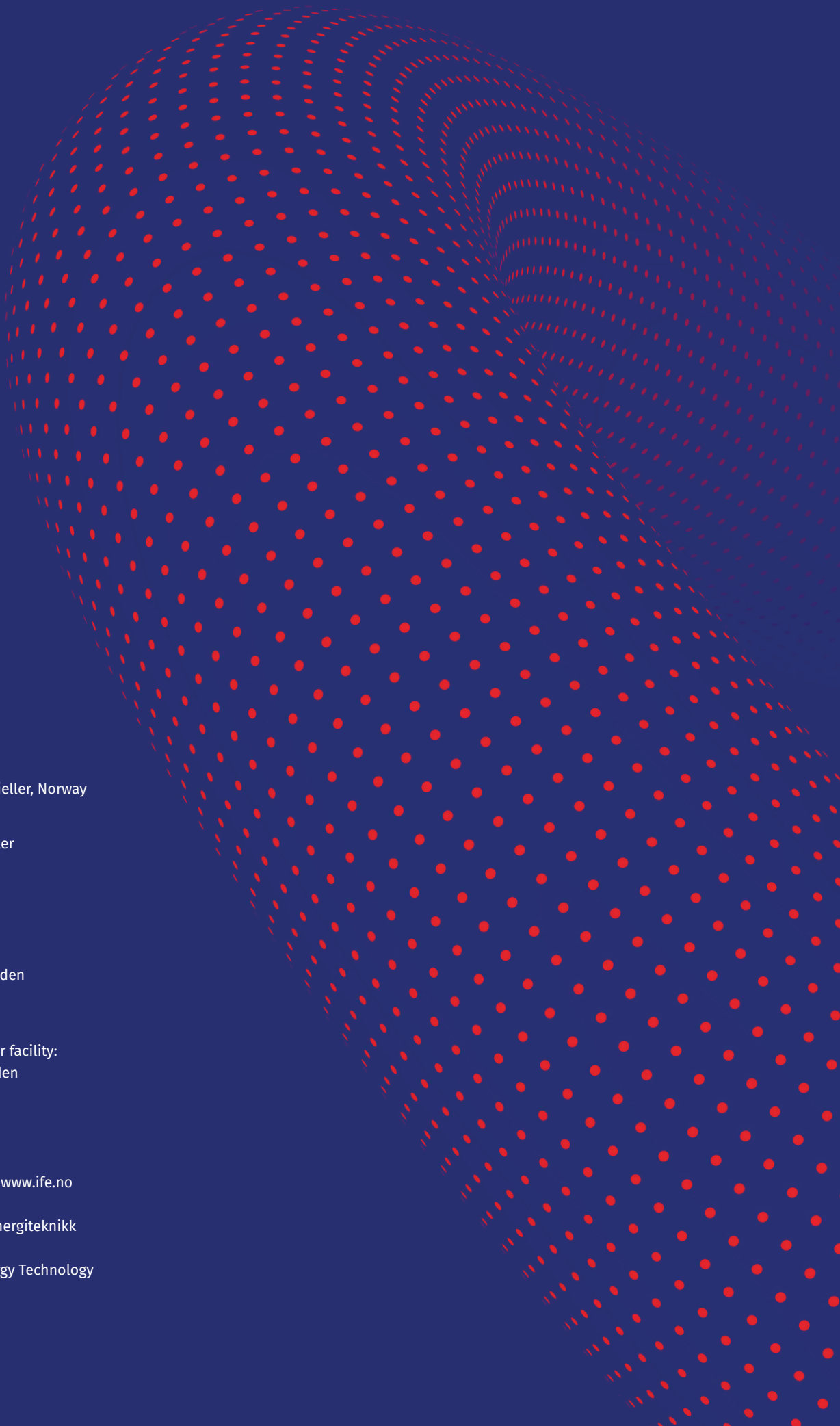
Johan Einar Hustad
Board Member

Camilla Tveiten Engeland
Board Member

Terje Bodal
Board Member

Kerstin Elisabet Dahlgren Persson
Board Member





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