



SINTEF ENERGY

Highlights 2015

About SINTEF Energy Research

SINTEF Energy Research delivers research-based systems and services that generate value for our clients. SINTEF Energy Research is a universally beneficial research institute which, by means of research, reports and information, contributes towards development within both the public and private sectors.

SINTEF Energy Research is a non-profit organisation and awards no dividends to its owners. Any resources generated by our activities are allocated solely for the purpose of achieving the institute's objectives. The institute is identified by the EU Commission as a non-profit organisation.

ORGANISATION

SINTEF Energy Research is part of the SINTEF Group and operates with four technical departments – Energy Systems, Electric Power Technology, Thermal Energy and Gas Technology.

SINTEF Energy Research is located close to the university campus at Gløshaugen in Trondheim. The SINTEF Energy Lab is located at Blakli, three kilometres south of Gløshaugen.

SINTEF Energy Research is owned by Energi Norge, Norsk Industri and the SINTEF Foundation. Turnover in 2015 amounted to NOK 397 million.

SINTEF Energy Research heads four of the Norwegian Centres for Environmentally-Friendly Energy Research (FMEs), and is involved in a total of six of the eleven centres nationwide. The aim of the FMEs is to address challenges in the fields of energy and the environment. Their work is carried out to the highest international standards. SINTEF Energy Research heads the four FMEs known as BIGCCS, NOWITECH, Cedren and CenBio.



SINTEF and NTNU have enjoyed a close working relationship since 1950, when SINTEF was established by the then Norwegian Institute of Technology (now NTNU). In this brochure you can read about the many projects and laboratories that we operate in close collaboration with NTNU.



SINTEF Energy Research at Gløshaugen and the SINTEF Energy Lab at Blakli.

New opportunities



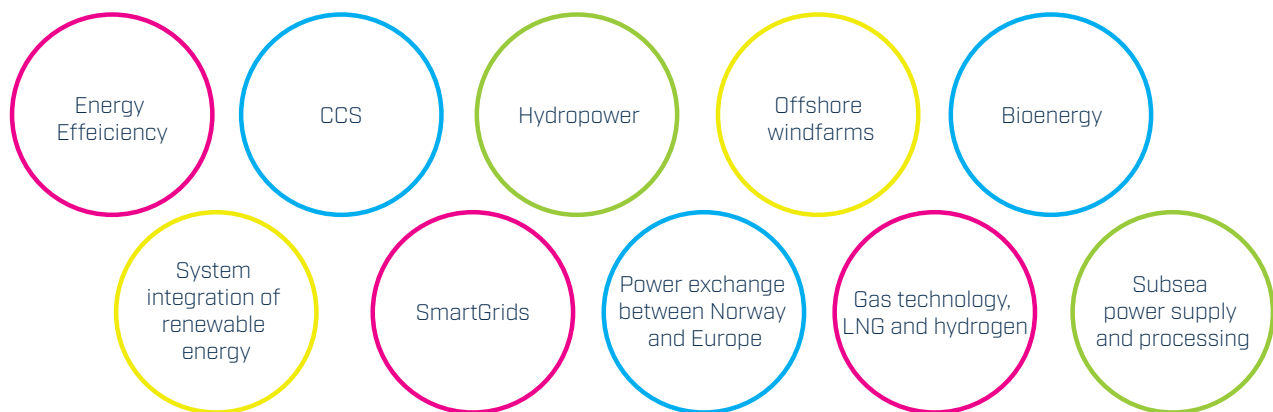
LONG-TERM PROJECT DEVELOPMENT

We take the long view, and are working strategically to ensure the establishment of an effective regulatory framework for energy research, as required by the industrial sector both here in Norway and in Europe. This work creates opportunities for submitting applications for the funding of research projects that are of value to the industrial sector.

Ninety-four per cent of the institute's revenues are generated via project development and sales

Ninety-four per cent of the institute's revenues are generated via project development and sales. Our basic funding represents about six per cent of our revenues. Our project portfolio is a combination of those funded entirely by industry clients, and industry-related projects financed in part by the public funding agencies.

We operate with ten areas of focus within which we carry out active project development.



SINTEF Energy Research's strategy

Objective: We shape tomorrow's energy solutions.

Our areas of focus contribute towards the transition to, and achievement of, future, sustainable, energy systems



MISSION INNOVATION

The current global economic situation has resulted in many companies cutting back on their research budgets in recent years. A massive fall in the oil price, as well as prevailing energy prices, both influence our clients' opportunities to invest in research. At the same time, the challenges created by climate change continue to attract major political focus in Europe, and this trend has intensified following the UN Climate Change Summit Meeting.

The world's largest research programme, Horizon 2020, is doubling its investment in the field of renewable energy. In connection with the Paris summit, Norway and 19 other countries signed a letter of intent to increase their research efforts in the field of climate change by one billion by 2020. The programme has been given the name Mission Innovation.



BLUE SKY PROJECTS

Basic funding is directed, among other things, to the development of new concepts within our fields of strategic focus that have potential for industrial wealth creation and benefits to society as a whole. **Here is an example:**

Nano HX

Effective and reliable heat transport is an important component of the Norwegian energy system. There will be specific requirements for high levels of reliability in particular in connection with applications such as subsea gas processing and the cooling of power electronics systems installed, for example, in offshore turbines.

Basic research carried out during the last decade has demonstrated the considerable potential for effective heat transport inherent in the properties of nanofluids. Moreover, there is a special type of nanofluids called ferrofluids, which can theoretically be used to produce a thermomagnetic pump. This is a heat transport pump without moving parts, which in principle can provide high levels of reliability and control.

The project, called NanoHX, involves the development of a numerical flow model designed to demonstrate the practical benefits of the concept and to facilitate the systematic optimisation of the concept. NanoHX has received pre-project funding to continue research during 2016 via the ENERGIX programme "New concepts". Read more about the project on the #SINTEFenergy blog at <http://blog.sintefenergy.com>

Communication



Dissemination of its institutes' results in the public domain is part of SINTEF's role in wider society.

The #SINTEFenergy blog was launched in December 2014. Here, research results are shared in both Norwegian and English (<http://blog.sintefenergy.com/en>).

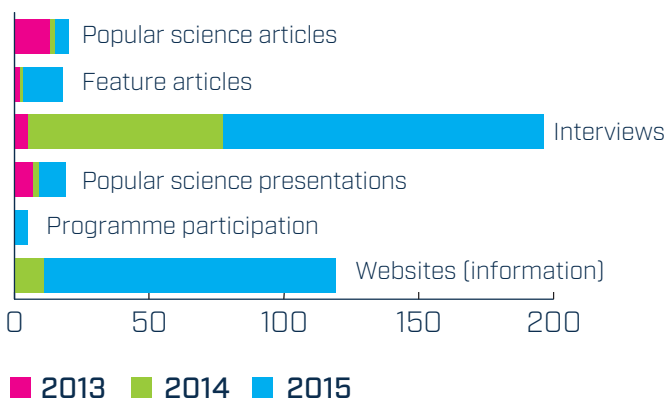
- In 2015, the blog received more than 37,800 unique hits
- To date, a total of 57 researchers have contributed to the blog
- In 2015, 108 blog posts were registered in the CRISTin system

SINTEF Energy Research has also been more proactive on social media in 2015, with scheduled posts on Facebook, Twitter and LinkedIn.

Followers (as of May 2016)



SINTEF Energy Research on social media



From Cristin

"LIGHTNING SMART" ADVICE

For some years now, on behalf of Statnett, Frank Dahlslett and Oddgeir Rokseth from SINTEF Energy Research have been monitoring and recording every lightning strike in Norway via the "Lyn-i-dag" (Lightning Now) service. Journalists have been contacting them around the clock to ask questions about lightning, and in years when lightning strikes are more common, Dahlslett and Rokseth have become among SINTEF's most quoted research scientists. From 1 January 2016 this service will be transferred to the Norwegian Meteorological Institute.

In November, almost the entire children's science TV programme 'Newton' was given over to an experiment carried out at SINTEF Energy Research. Newton wanted to find out if it was safe to sit in a car during a lightning strike. Our researchers Oddgeir Kvien and Erik Jonsson gave them the answer by creating lightning as part of a huge experiment conducted in the SINTEF Energy Lab.



Tomorrow's energy systems

On 24 November 2016, SINTEF Energy Research will be 65 years old. However, we have absolutely no plans for retirement. I am proud to be heading SINTEF Energy Research, and in 2015 we had many reasons to be proud.

In September, we opened the SINTEF Energy Lab. This new laboratory has cost NOK 170 million, and we've been saving for more than 60 years to build it. It was opened by their Royal Highnesses the Crown Prince and Princess. In his opening address, Crown Prince Haakon referred to Norway's status as an energy nation in possession of considerable natural resources. He said that these natural resources provide us with tremendous opportunities for wealth generation, but that we also have a responsibility to manage them not only for ourselves, but also for succeeding generations. He was optimistic for the future because Norway has exciting research centres, such as SINTEF, focusing on applied research. And I must say that I agree with him here.

SINTEF Energy Research is an international research institute. In 2015 we had projects involving 152 different international clients, and together we generated value both for business and society as a whole. Many of these are EU-funded projects that we have been involved in for many years. However, we intend to further consolidate our commitment to the EU, and for this reason now have two employees stationed permanently in our new office in Brussels. We believe that this will boost our chances of being awarded and receiving funding for new and exciting European research projects. Our Brussels office is located together with those of NTNU and the University in Bergen, and was officially opened in September.

In Paris just before Christmas, all of the world's 195 nations signed a joint climate change agreement. This is the world's first global climate change agreement, aimed at putting in motion the so-called "green shift" that everyone in Norway is talking about. Many countries, including Norway, also agreed to step up their efforts to develop climate change technologies by means of "Mission Innovation". We at SINTEF Energy Research, together with our clients, consider ourselves part of this global effort to develop the sustainable energy systems of the future.

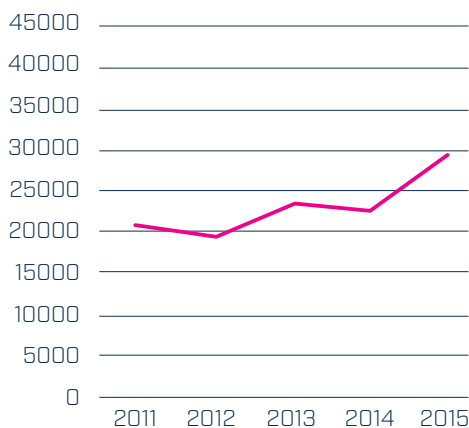


In this little brochure you can read more about the opening of the SINTEF Energy Lab, our new office in Brussels, and many examples of interesting projects we are carrying out in collaboration with the business sector.

A handwritten signature in blue ink that reads "Inge R. Gran". The signature is fluid and cursive.

Inge R. Gran, President.

SINTEF Energy Research and Brussels



EU-FUNDED PROJECTS IN 2015

In 2015 we participated in a total of 32 EU-funded projects, and acted as coordinator for six of them. In 2015, SINTEF Energy Research received grants for nine projects as part of the EU's Framework Programme H2020, and applied for funds in connection with seven others.

Development of SINTEF Energy Research's EU-funded project portfolio from 2011 to 2015 (in 1000 kroner).

OPENING THE BRUSSELS OFFICE

SINTEF Energy Research's office in Brussels was opened in September 2015 together with those of NTNU and the University in Bergen. Strengthened by its presence at the heart of the EU, SINTEF Energy Research is now a part of the secretariat to the European Energy Research Alliance (EERA).

This gives us the opportunity to play an active part in shaping the EERA's strategies and plans, as well as providing us with access to the key players developing the EU's SET Plan.

During 2015 SINTEF Energy Research has had meetings and conversations with the Research Council of Norway, the EU delegation (Ambassador, Energy Council, Research Council), the Confederation of Norwegian Enterprise (NHO), Abelia, Statnett, Statoil, Enova, Fjordkraft and Hydro og Agder Energi, among others. SINTEF Energy Research's office in Brussels is used as a centre for working on specific project proposals and initiatives, as well as a meeting place for researchers, business partners and clients.

H2020 – THE GATEWAY PROJECT: NO HOPE OF SUCCESS WITHOUT THE POLITICIANS

In connection with the UN's climate change negotiations in Paris, Norway's Climate and Environment Minister declared that he was positive to the storage of CO₂ in reservoirs beneath the North Sea. Such reservoirs can act as CO₂ storage sites for many European countries. Success for such a project requires that we find a profitable CCS management model as part of Norway's current energy system. We require the right regulatory mechanisms and public acceptance across Europe. It is these issues that are currently being addressed by the GATEWAY project. GATEWAY is a Horizon 2020 project, headed by SINTEF Energy Research. It currently involves five European partners. Project Manager Marie Bysveen from SINTEF Energy Research gave an address about the project to the European Parliament. She told the politicians, among other things, that research scientists are ready and able to carry out the best CCS research in the world, but that the project will not succeed unless decision-makers ensure that CCS technologies can be fully developed and applied.





SINTEF ENERGY LAB

It was back in 2013 that SINTEF Energy Research began construction of a new electrical power laboratory in Trondheim, designed to meet increasing demand.

The new lab was opened by H.R.H. Crown Prince Haakon on 2 September. Society at large relies on robust and reliable electricity supplies, and the new laboratory will host the testing and development of components for incorporation into the renewable energy systems of the future – both on- and offshore. In his opening address the Crown Prince referred to Norway's status as an energy nation in possession of considerable natural resources.

The new laboratory is the first of its kind in the world constructed according to 'passive house' principles. A total of NOK 170 million have been invested in the lab, which has been financed entirely by SINTEF Energy Research.



Unni Steinsmo guides the Crown Prince and Princess around the Sintef Energy Lab.

Photo: SINTEF/Torgim Melhuus

[From the #SINTEFenergy blog](#)

ECCSEL

In 2015, the Research Council of Norway granted additional funds amounting to NOK 153.9 million to the European CCS infrastructure project ECCSEL. SINTEF and NTNU are joint coordinators of this project.



THE SMART GRID LAB

The Research Council of Norway has granted NOK 28.6 million to NTNU to fund the establishment of a national laboratory for smart grid research in collaboration with SINTEF Energy, NCE Smart Energy Markets and Narvik University College. The new laboratory opens in 2016, and its infrastructure will be open to research centres and companies from all over Norway.

Clients and research

2015



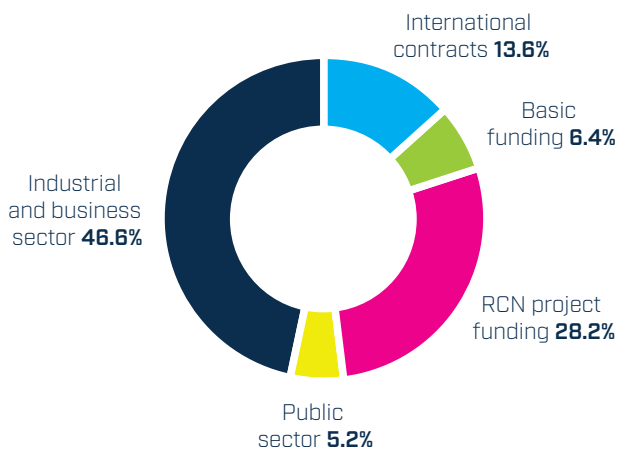
Projects **538**



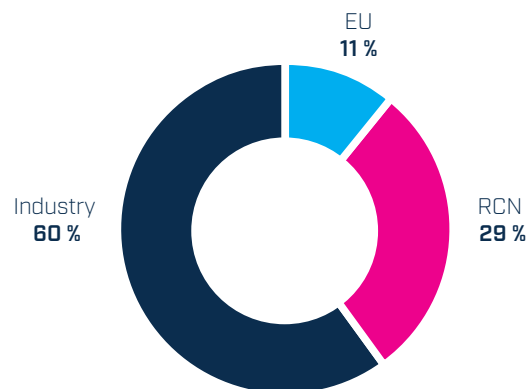
Clients **432**



International clients **152**



Allocation of revenues 2015



2015: Allocation of funding, 60% of projects carried out by SINTEF Energy Research are funded by industry

INTERNATIONAL COLLABORATION

In the future it will be important for the institute to adapt and focus on areas where it is or has the potential to be in the forefront of global research. Our clients will continue to an ever-increasing degree to seek out the best international research institutes. SINTEF Energy Research's focus on the industry's needs, combined with its close working relationships with industry partners, provides us with a good base from which to make the most of these opportunities. Fourteen per cent of the institute's turnover is generated from foreign organisations based in countries both inside and outside the EU. The most important among the latter are Japan and the USA. In 2015 SINTEF Energy Research attended two major events in Washington and Tokyo.

SINTEF ENERGY RESEARCH AND JAPAN

In May, many of our research scientists travelled to Japan in connection with the Japan-Norway Energy Science Week. They were both involved in, and responsible for, many of the conference sessions. The event was planned in close collaboration between the Research Council of Norway, Innovation Norway, the Norwegian Embassy in Tokyo and the Norwegian research centres.



In September, the offshore wind energy centre hosted a visit by partners from the industrial and research sectors as part of a research project looking into offshore wind farms and HVDC connections. The meeting was held at the SINTEF Energy Lab.

COLLABORATION WITH NTNU IN CONNECTION WITH THE FMEs

NTNU is SINTEF's most important research partner, most notably in connection with the FMEs (Centres for Environmentally-Friendly Energy Research), where collaboration is close at all levels.

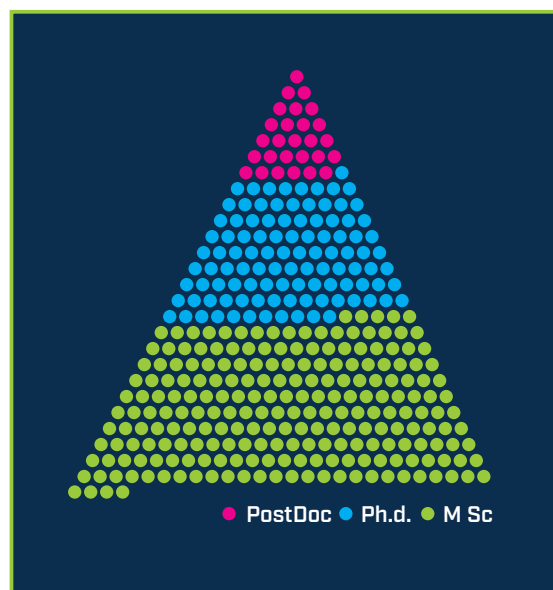
Since 2009, SINTEF Energy Research has headed the FMEs BIGCCS, NOWITECH, Cedren and CenBio. Innovation is a key activity at the FME centres, and all of them have succeeded in this field. To date, the centres have delivered a total of 143 innovations.

An important role of the centres is to make a contribution in their various fields of specialisation and, for this reason, education is of prime importance. NTNU has been responsible for most of the activity in this field.

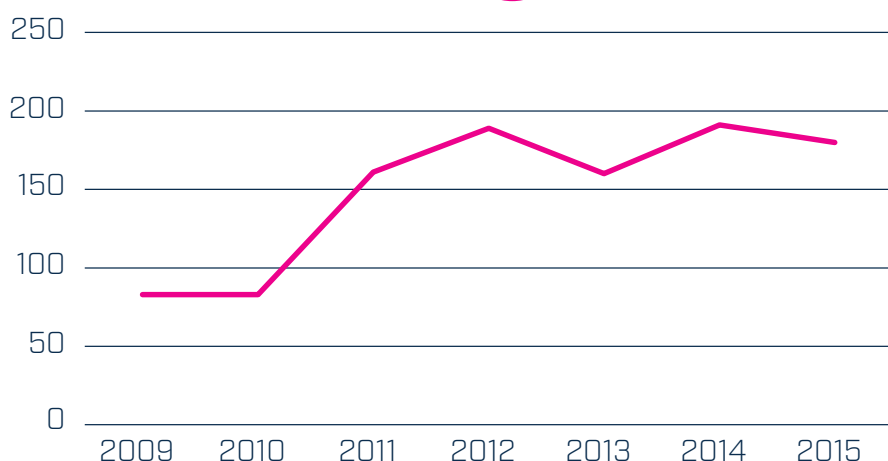


The FMEs have produced:

224 M.Sc., 104 Ph.D. and 27 Post-Doc. degrees



SCIENTIFIC PUBLICATIONS



In 2015, a total of 180 scientific publications were approved by the universities' assessment system.

INTERNATIONAL CCS CONFERENCE

In June, a total of 350 delegates from 26 countries attended the TCCS-8 conference with the aim of discussing recent developments in the field of CCS. A total of 138 presentations and 10 keynote addresses were given, together with more than 100 posters. The conference maintained a high scientific level.



Professor Gary T. Rochelle from the University of Texas in Austin received the SINTEF/NTNU 'CCS Award' for his contributions over many years to the field of carbon capture.

At TCCS-8 – Nikolai Astrup gave a talk on Norwegian CCS policy.

Photo: SINTEF/Svend Tollak Munkejord

UNFOUNDED DOUBTS ABOUT ELECTRIC CARS

The following is a summary of a feature article in the business daily *Dagens Næringsliv* [12 December] by Ove Wolfgang and Steve Völler:

If every other car in Norway is to be electric by 2020, this will boost production from coal-fired power stations across Europe. But climate change accounts will still be in the black. This is what researchers at SINTEF Energy Research discovered when they were deciding what new vehicles to purchase for the SINTEF Energy Lab.

Calculations made using the Grid Simulation Model, which SINTEF has developed as a 'crystal ball' for the electric power industry, show that half of this growth would come from coal-fired power stations that emit CO₂. But they also indicate an annual reduction of one million tonnes of CO₂ across Europe, which is equivalent to the sudden disappearance of 75 per cent of Oslo's greenhouse gas emissions. *You can read the article at [gemini.no](#).*



Infoto / Shutterstock.com

HYDROGEN POWER IS JUST AROUND THE CORNER

The following is a summary of a feature article in the business daily *Dagens Næringsliv* [4 December] by Sigurd Sannan:

Hydrogen is a highly reactive gas. Even very small concentrations are easily ignitable. This can cause so-called 'flame flashbacks' by which the flame in a combustion chamber propagates up into the supply system and, in the worst case, can destroy a gas turbine.

As a result of a joint study carried out with gas turbine suppliers and leading research centres in the USA, we at SINTEF have carried out detailed and computationally demanding calculations that have provided new and important knowledge about this phenomenon and its causes.

The industrial sector is now closer than ever to achieving the efficient and reliable combustion of hydrogen involving minimal emissions of environmentally harmful nitrogen oxides. As a result, another piece in the jigsaw that may be of crucial significance in the battle against climate change is in the progress of falling into place. *You can read the article at [gemini.no](#).*

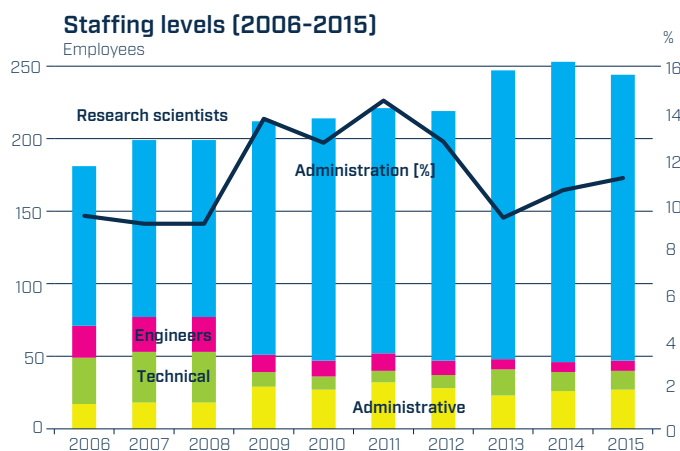
FLOATING WIND TURBINES AND GAS TO JAPAN?

The following is a summary of a feature article in the business daily *Dagens Næringsliv* [10 April] by David Berstad and Petter Nekså:

Norway exports large volumes of unprocessed natural gas and oil, as well as electricity. Japan, on the other hand, is a major net importer of energy and is preparing to welcome much of these imports in the form of liquid hydrogen. On their journey towards a low carbon economy, the Japanese are on the lookout for exporters who can produce hydrogen without CO₂ emissions. So, with a Japanese industrial cluster as its client, SINTEF has recently carried out an introductory feasibility study to find out if Norway could fill the role as producer. *Read the whole article at [gemini.no](#).*

People

At year-end 2015, SINTEF Energy Research had 244 employees.



THE SUMMER INTERN PROJECT 2015

Record number of applicants: In 2015, for the ninth year in a row, SINTEF Energy Research employed a number of summer research interns. The 300 applications for just 20 internships was a new record. The interns' work was very impressive, and we are proud of what they achieved.

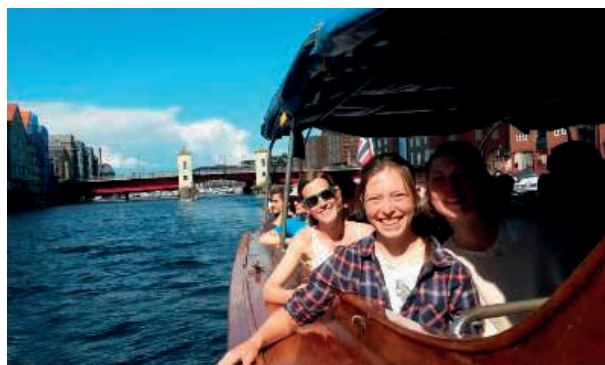


From being a small test project involving just a couple of students, summer project work has now developed into a major annual event that is well-known and well-reputed among both SINTEF researchers and the wider student community. Many of these students have subsequently joined the institute as permanent employees.

Summer interns and employees at SINTEF Energy Research after the 2015 Summer Research Conference.
Photo: SINTEF/Erik Børseth

YOUNG AT SINTEF

On 22 June the organisation Young at SINTEF at SINTEF Energy Research invited its members and the summer research interns to a boat trip and barbecue. The weather was fine and 29 people enjoyed the event.



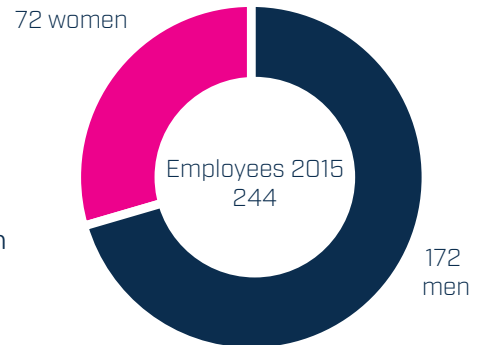


SINTEF POPULAR AMONG STUDENTS

For the first time ever, SINTEF tops the lists of where science and technology students at NTNU and the University of Oslo would most like to work. So says the 'Universum' survey' which questioned a total of 15,643 students studying 133 different courses.

DIVERSITY AND EQUAL OPPORTUNITY

SINTEF Energy Research's equal opportunity policy is fully supported by SINTEF Group Management. Our HR policy and administrative procedures meet all the requirements set out in the Norwegian Equal Opportunities Act. Thirty per cent of the institute's employees are women, and women make up 44 per cent of the institute's management team. As part of our recruitment policy, we are making every effort to increase the proportion of women at the institute, and have plans in place to promote career development among our senior female research scientists.



SINTEF ENERGY RESEARCH AT THE PARIS CLIMATE CHANGE SUMMIT

The UN COP21 Climate Change Summit was held in Paris in December. Prior to the conference, SINTEF Energy Research held a workshop for public relations staff working in the field of energy research at NTNU, NINA, SINTEF and the Research Council of Norway. As a direct follow-up from the workshop, the magazine GEMINI stepped up its spotlight on climate change issues in the months before the conference.

SINTEF Energy Research entered into a joint collaboration with the Research Council of Norway in connection with the 'Arendal Week' event attended by the then Norwegian Climate and Environment Minister Tine Sundtoft. Among other things, Vice-President Petter Støa and Director for Sustainability Nils Røkke spoke about balance power and CCS, respectively. In December, Nils Røkke was at the summit in Paris to give an address on the subject of CCS together with Bellona.



Tine Sundtoft was given special "negotiation cards" specially made for the occasion.



From the left: Anders Fylling (from SINTEF Building and Infrastructure), Nils Røkke and Petter Støa.



THE HEATUP PROJECT UTILISES WASTE HEAT

The idea behind the HeatUp project, launched in 2015, is to utilise the relatively large volumes of energy that industries dispose of in the form of waste heat because it is at the 'wrong' temperature required for their production processes. The aim is to recycle the energy, upgrade it, and make it useful by means of heat pumps.



The project, which is in part funded by the Research Council of Norway, is headed by SINTEF Energy Research. It has attracted a number of industry partners such as Statoil, Statkraft, Tine, VeddeAS, Hydro and Mars Petcare, just to mention a few.

Project Manager Petter Neksa at SINTEF Energy Research is keen to develop not just one, but several systems as part of the HeatUp project. Different industrial processes have different heat requirements. For example, Statkraft needs to upgrade waste heat to about 70°C for its district heating plants, while a food-stuffs company will need upgrades to 120°C to produce low-pressure steam, which is a key component in a range of drying technologies.

STOP – HEATING FORESTRY WASTE TO PROVIDE MORE ENERGY

A method similar to the roasting of coffee beans may enable us to heat treat raw or unprocessed biomass. The result is a fuel with a range of useful properties. The process is called torrefaction.

As part of the STOP project, which was completed in 2015, SINTEF has accumulated such comprehensive knowledge about this process that it has made a contribution towards development in this field. The aim of the project was to achieve stable operational levels at bioenergy facilities that produce heat, or heat and electrical power



The process of low-temperature torrefaction is similar to that of roasting coffee beans.

(Illustration: SINTEF/Kjetil Strand)

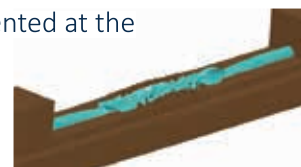
Project: STOP

UNDERSTANDING THE FORCES AT PLAY WHEN BOILING CO₂ DRIVES A RUNNING PIPELINE FRACTURE

In order to transport large enough volumes of CO₂ in pipelines of reasonable dimensions, it is necessary to compress the gas to form a liquid at pressures of about 100 atmospheres. A key safety aspect of high-pressure transport of this type is a phenomenon called 'Running Ductile Fracture' (RDF).

A key pipeline design criterion is to ensure that a running fracture can be arrested and prevented from propagating for long distances along a pipeline.

SINTEF Energy Research and SINTEF Materials and Chemistry have developed an advanced RDF model as part of the BIGCCS FME. The model was presented at the TCCS-8 conference in 2015.



When such an incident occurs, a minor crack in the pipeline starts to propagate in both directions along its length. In the worst case, the fracture can open up along the pipeline for distances of hundred of metres, resulting in major and hazardous leakages.

Illustration: SINTEF

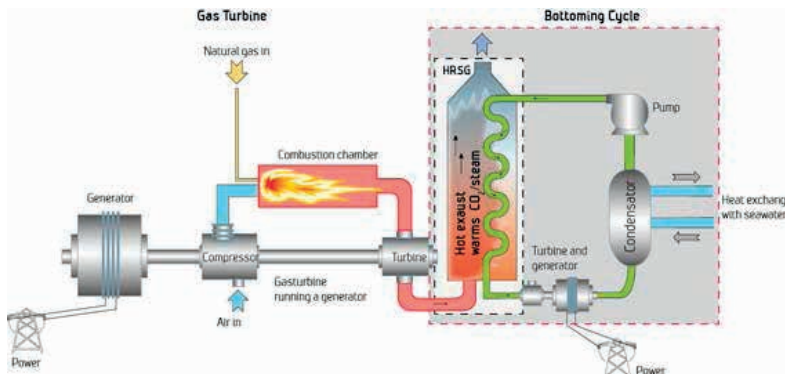
Project: BIGCCS

COMPACT OFFSHORE STEAM CYCLES – WASTED HEAT RECOVERED

The oil and gas industry accounts for 26 per cent of man-made greenhouse gas emissions in Norway.

Eight out of ten kilograms of CO₂ emitted on the continental shelf is derived from gas-fired power generation taking place on oil and gas platforms. Part of the heat produced is used to treat the oil and

gas in situ on the platforms, but in most cases potentially useful waste heat is discarded. If the waste heat can be recycled to produce additional power, the platforms will require less gas for energy production, and their power plants will be able to achieve 25 per cent reductions in CO₂ emissions.



This is the result of a study called COMPACTS that we at SINTEF are carrying out jointly with the oil industry, funded by the Research Council of Norway.

Project: COMPACTS

From the #SINTEFenergy blog

WORLD RECORD IN WIRELESS ENERGY TRANSFER

In the future, if everything goes as planned, we will soon see the wireless battery charging of Norwegian fjord ferry services. This wireless, or inductive, energy transfer technology is planned to have an output of 1 megawatt, equivalent in size to 300 times that of a current standard electric car battery charger. The project 'Wireless high power battery charging for ships' has already produced a small prototype, built by SINTEF Energy Research.

"We are talking about a new approach to designing systems for the wireless transfer of electricity, involving major variations in distance and location", says Jon Are Suul at SINTEF Energy Research.

"We have tested a small prototype in the laboratory and it's working just as we expected. A patent application has been filed", he says.



"The project is breaking new ground", says Ingve Sørffonn, Technical Director at Wärtsilä Norway, which was SINTEF's client in connection with this project.

The battery-driven ferry Ampère, which plies cross Sognefjord, represents the world's first step towards electrification of coastal vessel traffic. And the next stage is already underway in the form of a Norwegian research project looking into the wireless charging of battery-driven vessels.

Photo: Norled AS

Project: Wireless high power battery charging for ships



SINTEF Energi AS

www.sintef.no/energy

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Front cover: Nina Sasaki Støa-Aanensen at the electric power laboratory during her doctorate studies.

She submitted her thesis to NTNU, entitled 'Air Load Break Switch Design Parameters'

Photo: NTNU/Geir Mogen



Design and print: www.fagtrykk.no

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