ANNUAL REPORT

2018

HydroCen

NORWEGIAN RESEARCH CENTRE FOR HYDROPOWER TECHNOLOGY

CENTRE FOR ENVIRONMENT-FRIENDLY ENERGY RESEARCH

HydroCen is a research centre for environmentally friendly energy. Our main objective is to enable hydropower to meet complex challenges and exploit new opportunities through innovative technological solutions.

The main research partners in HydroCen are The Norwegian University for Science and Technology (NTNU), SINTEF Energy Research and Norwegian institute for nature research (NINA). The centre has a total budget of 400 million NOK over eight years and is financed by the Norwegian Research Council (50%), the research institutions (25%) and partners from the hydropower industry (25%).

WP 1
Hydropower structures

WP 2
Turbine and generator

WP 3
Market and services

WP 4
Environmental design

Ivar Arne Børset
Statkraft

FROM THE BOARD

We are proud to see that HydroCen in its second year of operation is handling a large portfolio of research projects and is already showing its potential as a driving force for hydropower development through extensive fieldwork, collaborative workshops and initiation of new activities.

This year HydroCen has positioned itself internationally, creating enthusiasm for hydropower research both politically and within academic communities.

Smart, flexible and reliable renewable energy is a priority for the EU and HydroCen has become a hub for coordinating hydropower research by founding and leading the Joint programme for Hydropower in EERA, the European Energy Research organisation. Stakeholders from countries such as USA, Australia and India have also committed to collaborate with HydroCen.

It is also gratifying to acknowledge that all the projects in the centre have started their research, and that HydroCen has managed to recruit new PhD-candidates at an impressive scale both in regard to time and quality.

Times are shifting ever more quickly, and this definitely applies to the future role of hydropower. Thus, in 2018 we have prioritised time to discuss strategy and future plans to be able to meet the upcoming needs in a rapidly evolving energy and climate discourse.

The Board appreciates the close cooperation and fruitful discussions with the management team, work package leaders, members of HydroCen and our stakeholders.

Looking forward, we expect 2019 to be a year where scientific excellence is the focus, as many of the projects are approaching the stage of experimental testing in the laboratories, data-analysis and field measurement and monitoring. We look forward to follow this work, and to eventually present the results.

On behalf of the Board
Ivar Arne Børset, Chair
SVP Operations and Maintence management, Statkraft.

Hege Brende
Executive Director,
HydroCen

FROM THE DIRECTOR

Once again we can look back on a great year for hydropower research.

Our research aims to investigate the new role of hydropower in the future energy system. The future is uncertain in regards to climate change and sustainable growth, where clean energy for all is one of the major, and critical, challenges of our time.

Globally, hydropower generates ~62 percent of the renewable electricity share. In Europe hydropower amounts to ~50 percent, and in Norway this is ~96 percent. In short, hydropower is the major supplier of renewable energy in the world.

In this respect, our research on hydropower is key to meet UNs sustainable development goals and accelerate the transition to a clean energy system. Hydropower has some unique capabilities for flexibility and regulation.

This can be demonstrated across time, scale and characteristics. A hydropower unit with a turbine, generator and converter can be optimized to deliver and absorb energy in order to regulate grid frequencies down to milliseconds. A hydro tunnel can be designed to handle large and frequent fluctuations in the flow in order to start and stop the machines whenever needed to optimize operation and take advantage of new markets. A large hydropower reservoir scheme can store energy for weeks, months and even seasons.

New methods for fish migration and operations of reservoirs and watercourses mitigate and avoid environmental impacts. New models for hydro scheduling and market design secure profitability and future investments in renewable hydropower. Innovative solutions for sediment handling and water management secures that future development of hydropower is sustainable.

I am very proud to lead this fantastic group of experts and industry in HydroCen!

Their willingness to engage, be creative, challenge and work together across disciplines ensure that we deliver on our targets and our mission to define and enable the new role of hydropower in the clean energy system.

The second year of operation has been a blast – enjoy this report to get a small glimpse of our portfolio of activities and deliveries!

Hege Brende
Executive Director, HydroCen

Vortexes, louvers and bubble-walls were some of the suggestions put forward when HydroCen researchers discussed possible new solutions to prevent fish from entering power stations and embarking on the often-fatal turbine passage.

Previous research has shown that scaring fish is an inefficient way of influencing fish behaviour, so now experts for several diciplines pool their resources to guide fish from fatal turbines.

Photo: Marcell Szabo-Meszaros / Geir Mogen, NTNU

UNIQUE MEASUREMENTS TO DETERMINE TUNNEL DURABILITY

Norway has 5000 km hydropower tunnels. Now HydroCen researchers seek to know how robust they are, and if they have an expiry date.

Once every 15 years Sira-Kvina stops the water at Roskrepp power station to do maintenance. This time they let researchers have a good look around.

— It is very exciting. We don't really have a clue how long Norwegian hydropower tunnels can last. Many of them are already 100 years, but do they have an expiry date? That is the big question, says Kaspar Vereide.

Vereide is involved in several HydroCen projects as associate professor at NTNU and project developer at Sira-Kvina Kraftselskap.

— This research will help us find some answers towards determining the robustness of hydropower tunnels, he says.

It takes about 3 hours to walk down the four-kilometre-long tunnel, wading through the pools of water that remain in rough surfaces.

Engineering geologist, and professor, Krishna Panthi has already checked that the passage is safe.

— This tunnel is in very good shape, he reassures the expedition heading into the darkness.

For many years Panthi has worked towards this research opportunity: To investigate how the pressure in hydropower tunnels affect the pore pressure in the rock mass. It has never been done before, neither in Norway nor internationally.

MEASURING PRESSURE CHANGE

With help from several HydroCen researchers and employees from Sira-Kvina kraftselskap, PhD candidate Bibek Neupane has installed high-tech measuring equipment in the rock mass inside the tunnel.

Now steel pipes are fitted inside five boreholes in the rock mass with lengths varying from five to eleven metres.

They are custom-made pipes with rubber seals or «packers » fixed inside the boreholes so the the water from the tunnel does not leak directly into the boreholes.The borehole length outside the packer is also sealed with cement for additional safety.

A separete pipe is also installed in the tunnel to simultaneously measure the water pressure there.
— When you start or stop the production in the power station there is a pressure change in the tunnel. We want to measure if these pressure variations influence the pore pressure in the rock mass, he says.
It is literally tons of water that experience sudden changes in the flow, so the force can be enormous. The sensors are connected to an advanced data logger outside the tunnel, so the researchers can follow the pressure variation data in real time when the power production starts, stops or varies. Ten pressure readings every second from each sensor are being recorded by the data logger as we speak.

WILL THE TUNNELS HANDLE THE OPERATION SCENARIO IN THE NEW TIMES?

The rough tunnel roofs towering over the researchers has kept well since the production started here in the 1980's, but tunnels operating today are under a lot more stress than they were originally built to handle. In the 1990's the power market was de-regulated, consequently leading to a lot more variable operation of the power stations.

— Historically power production has been very even, we haven't stopped and started the water a lot, but since the 1990's power systems have been operated more aggressively, says Vereide.

Rock mass in Norway is strong and dense, but hardly any tunnels are built for this type of variable operation.

— Turbines and tunnels experience much more stress now. It is this stress we are trying to measure and survey to see how it influences the tunnel, says Vereide.
The pressure in the tunnel changes very fast when the water is stopped.
— It can go from 70m^3/s to 0 m^3/s in about ten seconds, so the water comes to a sudden stop and builds a massive force.

— It can be compared to a full freight train speeding through the tunnel, suddenly comes to a full stop.
Large and frequent pressure changes can lead to unstable rock mass.

— It is really good that we get to do these tests now, says Vereide.

— The goal is to see how robust the tunnels are, what pressure changes they can handle and how much we can vary the power production without severe consequences for the long-term stability of the rock mass, says Neupane.


Bibek Neupane


Krishna Panthi


Kaspar Vereide

WHAT WILL BE THE VALUE OF FLEXIBLE RENEWABLE POWER IN THE FUTURE?

Researchers have collected data from industry, the European Commission and several other research projects, and are making advanced data models to predict what will influence power prices in the future.

By making qualified assumptions of how the European power market will develop towards 2030, we can also calculate future prices in Norway.

The ultimate goal is to analyse different scenarios, and possible values from different markets to better understand the value of making changes in the power system.

Forecasting future prices is challenging and SINTEF-researchers Linn-Emelie Schäffer and Birger Mo cooperate with many other researchers and projects to draw mutual benefits.

MASTER STUDENTS SOLVED THE SMELAND PUZZLE

For many years Smeland Kraftverk experienced vibrations during full load-production. Many have tried to figure out why this happened and how the vibrations could be reduced or eliminated. The solution came when two master students arrived to do tests.

Photo: Ole Gunnar Dahlhaug/NTNU

Together with operating personnel from Agder Energi and researcher, the students, Johannes Kverno and Vegard Ulvan, discovered how these vibrations can be attenuated.

They were challenged by Agder Energi to carry out measurements at Smeland Kraftverk to find the cause of the vibrations. On February 21, they performed efficiency and pressure pulsation measurements with Professor Ole Gunnar Dahlhaug.

During discussions between Agder Energi's operating personnel and NTNU a decition was made to try air and water injections into the suction pipe through the impeller. The water injection did not mitigate the vibrations, but the air injection had a surprisingly good effect.

The students will document how good the mitigation was and if the air injection had any effect on the efficiency.

NEA RIVER

A NEW CASE STUDY FOR HYDROCEN

HydroCen puts forward its full capacity of knowledge to research consequences of power production in inland river systems

In cooperation with Statkraft and local partners, researchers will use the Nea river as a case study for multiple research projects in the coming years.

— We see this as the perfect river system to develop the concept of environmental design , says Ove Berggård, director at Nea power station.

The river is regulated with several reservoirs in the upper part of the catchment and a series of power plants further downstream. It is mainly the demand for electricity that decides the water flow in the river

Broader Environmental design

Hydropower production impacts the environment in all rivers.

The goal of environmental design is to ensure a healthy environment in and around the regulated rivers. Through the FME CEDREN, researchers developed the concept of Environmental design in regulated rivers, and even produced a handbook for environmental design in salmon rivers. HydroCen develops the method one step further, aiming at producing methods, tools and guidance for other users and services

— There is more than salmon in the river, there is even more than fish in the river, says senior researcher Torbjørn Forseth, Norwegian institute for nature research (NINA). He leads the work on environmental design HydroCen. Engineers, hydrologists, biologists, and social scientists will investigate conditions for trout, benthic fauna, ecosystems, and human activity in and around the river, as well as taking into account the services provided from the regulation like electricity and power when it is needed, flood and drought control. They will also develop new methods for surveying and mapping rivers, and easy-to-use tools for decision makers, power producers, and researchers.

Environmental design is like taking the river to the doctor. Scientists find out what are not working well to determine a diagnosis, and then try to implement mitigation measures to make the river healthy again. One measure could be using the water itself differently.

— With knowledge of when fish or nature need more or less water, the power producers could use the water smarter, says Forseth. It could also be physical measures.

— One can make changes in the river with excavators, construct shelters for fish, introduce spawning gravel and similar things, says Forseth.

From aesthetics to ecology

Social science is also included in the improved methods for environmental design

— People here practically live on the river, that makes this location interesting for social scientists as well, says Berggård. Researchers Margrete Skår and Berit Köhler are looking into recreational interests around regulated rivers

— American researchers have done a lot of research on activities like rafting and fishing in regulated rivers, but no one has asked how people walking and hiking relate to rivers, says Skår. Hiking is an extremely popular activity in Norway, and more than 90% of Norwegians say that they go for hikes or walks.

— We think that kindergardens, schools, and individuals actively use these areas, but since they aren't organized in interest groups, researchers don't know a lot about how they use the area, she says.

Local research for universal methods

Locally people will notice researchers both in, around and over the river. Researchers will also use drones and airplanes to scan the river with green laser technology (LIDAR).

— The goal is to obtain detailed information on physical conditions in this river system and contribute with new knowledge, better methods and measures in the years to come, says project leader Atle Harby, senior researcher, SINTEF Energy.

— We are also working with highly qualified international partners, who are experts on mapping rivers with drones and satellites, he says.

— The goal is to put forward the full extent of our combined knowledge in HydroCen. This way we can further develop environmental design and make tools that are useful in other regulated rivers as well.

Torbjørn Forseth

Atle Harby

Researchers 3D-scanned the whole tunnel at Roskrepp power station. This is a case study for two PhD's in HydroCen: Measuring long term robustness of tunnels in start-stop power production and new design conceps for surge chambers and penstocks in pumped storage plants.

Photo: Sira-Kvina Kraftselskap

EU ACCEPTS CALL FOR EXTENSIVE HYDROPOWER RESEARCH COOPERATION

Europe's largest energy research community, EERA, decides to establish a Joint Programme on hydropower after initiative from HydroCen.

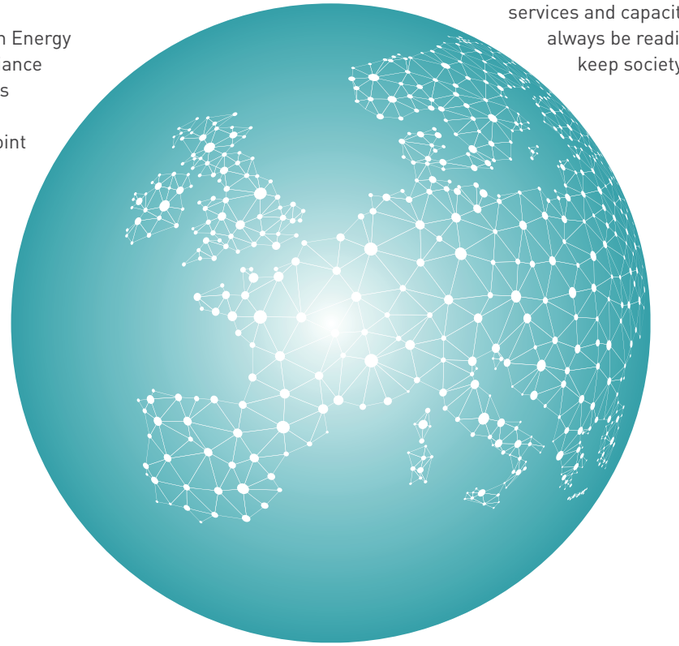
— In the EU, and the world, hydropower is the major technology for producing renewable electric energy. We are happy that it is back on the European research agenda, says Hege Brende Executive Director of HydroCen, the Norwegian Research Centre for Hydropower Technology.

Programmes already include research on smart grids, wind energy and solar power, to name a few.

— These new technologies will play a major role in realizing the goal of becoming a low carbon society. However, the rise of intermittent energy production such as wind and solar, also presents a new reality for the energy system, says Brende.

A fully renewable energy system demands flexibility at a new level. Energy storage, system services and capacity output must always be readily available to keep society on operation.

The European Energy Research Alliance (EERA) and its influential network of Joint



NETWORK OF EXCELLENT RESEARCH

Hydropower delivers 50% of the renewable electric production in Europe, and it can have an impact on the entire energy system.

— Across Europe several research institutions are now looking for solutions and innovations to make that possible, says Brende.

26 partners from 13 countries contributed to the proposal and came well prepared to the recent meeting with The Executive Committee in EERA.

— Hydropower is a technology that is already employed and invested in, it is highly effective and reliable, says Pål-Tore Storli, associate professor at NTNU and science coordinator.

There are, however, some technological constraints that need to be lifted for hydropower to fulfil the role as a flexible player in the future system.

— Flexible power production can lead to rapid variations in waterflow and impact the environment further, and there are electromechanical challenges that need to be solved, as well as finding better ways to predict fluctuations in the market, says Storli.

INFLUENCE THE ROADMAP TO THE FUTURE

— Our opinion is that we need to take a broad approach, so working together across disciplines and borders is essential, says Hege Brende.
She was rewarded for this approach when the EERA Executive Committee made their final decision.

— Congratulations! The main work is now ahead of you!

EERA General Secretary, Adel el Gammal, brought the good news from the Committee.

— The Joint programs represent the leading edge of their research fields. They represent scientific excellence.

The feedback we get from institutions and participants tells us that it is extremely rewarding from a scientific perspective, says Gammal.

— From a political perspective EERA is becoming increasingly influential.

— Over the last two years the profile of the organisation has rised to become an operative body within the context of the EU energy strategy, says Gammal.

INTERNATIONAL INTEREST IN HYDROCEN

More and more countries look towards hydropower to be an enabler in the renewable energy system. In 2018 HydroCen has taken many steps forward to increase collaboration on hydropower research worldwide. There has been researcher-to-researcher cooperation, PhD- and researcher exchange and signing of several MOUs with universities and policy makers. Here are some excerpts from the activities in 2018

CANADA:
Meetings with the HYCANOR-associates in the INTPART-research exchange programme.

USA:
Visits with the US Department of Energy, who are updating their hydropower strategies.

BRAZIL:
Meetings with CEPEL (Electrical Energy Research Center) possible cooperation on developing models for hydropower planning.

SWEDEN, UPPSALA UNIVERSITY:
PhD-exchange to do laboratory measurements on the generator test rig "Svante" to verify results.

POLAND, GDANSK:
HydroCen-stand at Hydro 2018, and several presentations by HydroCen researchers and partners.

NEPAL, KATHMANDU:
On behalf of NTNU, HydroCen has signed an MOU with Himalayan University Consortium, which represents almost 50 universities in the region. The Energize Nepal-project is also going very well.

INDIA, ROORKEE:
NTNU signed an MOU with the Indian Institute of Technology Roorkee. They will work together with HydroCen researchers and Kathmandu university to develop sediment resistant Francis turbines and new methods for data collection and modelling.

EU:
Establishment of Joint Programme Hydropower in EERA.

SWITZERLAND, ZÜRICH:
PhD-candidate Ola Haugen Havrevoll spent time at ETH in Zürich as part of his PhD-research on sediments in hydropower tunnels.

ALBANIA, MOGLICË:
Instrumentation at Statkraft power station in Moglicë where PhD Lena Selen is investigating effects of swelling rock mass on stability and support.

AUSTRALIA:
Meetings and cooperation with Hydro Tasmania, and MOU with the state government of Tasmania.

IMPRESSIVE IMPACTS FROM ENERGY RESEARCH

Hydropower is one of the areas that profits the most from research

Hydropower research has led to a value creation of seven billion NOK since 2008, concludes a study commissioned by the Norwegian Research Council and the Ministry of Petroleum and Energy. The study further estimates a value potential of another 10-20 billion NOK from already known innovations.

The goal of the impact-study was to «document the effects from investments in R&D (Research and development) in environmentally friendly energy ». Since 2007 the Norwegian research council has spent four billion NOK on energy research and the study shows that the realized economic return is 16 billion NOK.

— It is hardly possible to make a better investment, said Minister of petroleum and Energy Kjell-Børge Freiberg when he received the study from the Norwegian Research Council.

The study documents positive and potential financial effects of energy research, as well as increased security of supply, more renewable energy, reduced emissions and further development of knowledge and research.

— This study is a great tool for us. We spend a lot of money on research, and it is important for us to see what we get out of it, said Freiberg.

Hydropower research most profitable

The agencies Impello and Menon completed the study with input from eight disciplines, among them hydropower. HydroCen suggested six different programmes to look into based on research from the partners in HydroCen, NTNU, SINTEF and Norwegian Institute for Nature research: Francis turbines, the Environmental design handbook (CEDREN), PlaF, Fault detection in generators (Monotor X and HydroCen WP 2.4), rocktraps (FlekS) and SHOP.

Hydropower was one of the areas that profited the most from research.

Future value

In the coming years, HydroCen's research is expected to contribute, among other things, to better methods for making decisions by government and industry. Norwegian hydropower needs to be equipped for a more flexible energy system with more intermittent energy supply, ensuring reduced costs for maintenance and rehabilitation and more knowledge about how nature and people can live well with regulated rivers and watercourses.

3 WAYS TO MAKE AIR CUSHION SURGE CHAMBERS GREAT AGAIN

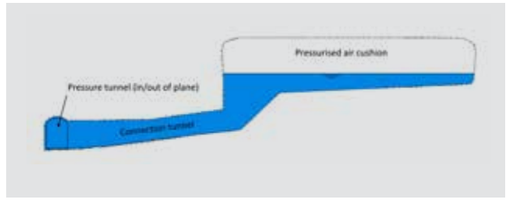
Unlined air cushion surge chambers (ACSCs) were first developed in Norway and are regarded internationally as a Norwegian specialty. Despite their many benefits they have traditionally been associated with geotechnical risk and potential costs, and none are built the last 30 years. Three specific suggestions for improved design might make them a more attractive option:

For a football to function perfectly it needs the right amount of air and as little leakage as possible. The same goes for air cushion surge chambers: The pressure needs to be just right, and leaks need to be kept to a minimum. The challenge is that ACSC's, unlike footballs, don't have valves, are rarely air tight and take a very long time to fill. For the owner of a hydropower plant this means great costs and considerable uncertainties.

However, three design improvements might eliminate these disadvantages:

1. *Install a plug and closing mechanism between the pressure tunnel and the ACSC*
2. *Seal the rock mass around the chamber by grouting to reduce air leakage*
3. *Design the chamber so that the stress field of the rock mass surrounding it helps keep the air inside*

Proposals 2 and 3 can reduce air leakage, and thus, the risk when constructing new ACSC's. Proposal 1 can considerably reduce the outage when associated with ACSC's. A plug will make it possible to retain the air inside even if the tunnel is dewatered, avoiding the need to empty and refill the air cushion chamber. Such a plug may be useful for both new and already existing air cushions surge chambers.



Kvilldal hydroelectric plant as a real-life example

Kvilldal hydroelectric plant has the largest ACSC in the world.

The cost connected to the ACSC during routine emptying and filling procedures are calculated to about 10 million NOK. Calculations show that investing in a plug mechanism yields a marginal profit. We also argue that by including the extra cost of unexpected and acute need for emptying the pressure tunnel as well as other positive effects, such as improved regulatory capacity, investing in a plug at Kvilldal is economically viable.

The text is based on a conference article presented at Fjellsprengningskonferansen 2018. Authors: M.Sc. Henki Ødegaard, PhD-student at HydroCen and Dr. Kaspar Vereide, associate professor at NTNU and project developer at Sira-Kvina kraftselskap.
Read the full text at hydrocen.blog/category/vannkraftkonstruksjoner/




SCIENTIFIC COMMITTEE ESTABLISHED

Four excellent scientists from different fields of expertise have taken on the challenge of reviewing HydroCen's research and results.

The first meetings were held in Trondheim, where they were presented with ongoing, and planned, research projects.

– HydroCen provides an exceptional framework for the advance of hydropower research and development. I'm excited to be part of it, says Juan Ignacio Pèrez- Diaz, professor at Universidad Politécnica de Madrid and expert in power systems- and scheduling.

Results will be useful world wide

– HydroCen is a massive project that aims at a better, more flexible utilization of hydropower. It is focused on the industry in Norway, but the results will be useful worldwide, says Niels Jepsen, sr. researcher at Technical University of Denmark and expert in aquatic ecology.

– The objective for the Scientific Committee meeting is to review future research proposals and assess their potential and the results. While the size of the project and the expertise of the scientists involved promise good specific results. The great challenge is to tie the different disciplines together to achieve truly transdisciplinary progress. We, as the Scientific committee, will do our best to assist in this process and hope for good communication between the different parts of this large project, says Jepsen.

Unique opportunity

The four members came well prepared and had fruitful discussions already in the first meeting.

– HydroCen provides a unique opportunity for energy and environmental research, which else would not be possible, says Thomas Staubli, professor at Luzern University and expert in mechanical engineering.

– So many different topics – that´s a great challenge and a unique opportunity, says Marcus Aufleger, professor at University of Innsbruck and expert in hydraulic engineering.

The Scientific Committee will give a first report with their comments on project plans and research, and the next meeting is set for September 2019.

Ana Adeva-Bustos

SINTEF Energy,
Research Scientist

What is your assignment/
expertise/contribution in HydroCen?

I am contributing to the environmental design research area, working in the AlternaFuture project. The river investigated in this project was also one of the case studies for my PhD. I have experience in the identification of hydrological and habitat bottlenecks related to hydropower regulation, which is one of the tasks inside the AlternaFuture project. In addition, I will contribute to the remote sensing tools also inside the environmental design research area.

What is your motivation to be a part of Hydrocen?

I am interested in working in projects that combine socio-economic benefits from water resources services, such as the trade-off between energy production and environmental impacts. In addition, I like that the AlternaFuture is a multidisciplinary project. I think it is a great opportunity to learn from each other and to demonstrate that the collaboration and understanding among the different groups and disciplines makes it possible to investigate large scale environmental design projects contributing to their success.

What are your expectations for HydroCen looking forward?

I am looking forward to this year, to see the outcomes from AlternaFuture, but also for future projects and collaborations in the coming years.

Jonas Kristiansen Nøland

Associate Professor
NTNU

What is your assignment/
expertise/contribution in HydroCen?

Generator technology and Excitation systems. Main supervisor of a new PhD position: «Optimal Utililization of Smart Generators». Supervision of new Master projects.

What is your motivation to be a part of Hydrocen?

I am very passionate about future Hydropower. There is still a lot of potential from the electrical point of view, and espechially in the interplay between the generator and the power grid. I look forward to take part in the new research projects and also to be able to learn from other areas of research within the center.

What are your expectations for
HydroCen looking forward?

I will be active and contribute in different strategic projects within HydroCen. It is exciting to see that the new interdisciplinary projects have been fruitful so far. I expect that they will generate new ideas that will strengthen our competence and create value for the industry.

Tom Jacobsen

Technical director and
founder of SediCon AS

What is your assignment/
expertise/contribution in HydroCen?

SediCon is based on research and we have delivered in-house developed sediment handling technologies and solutions to more than 20 countries worldwide. However, we have delivered very little in Norway. Yet we know that Norwegian companies and Norwegian projects need sediment handling as well, typically for brook intakes, intakes downstream of glaciers and tunnel desanders. We want to make our international experience available to HydroCen

What is your motivation to be a part of HydroCen?

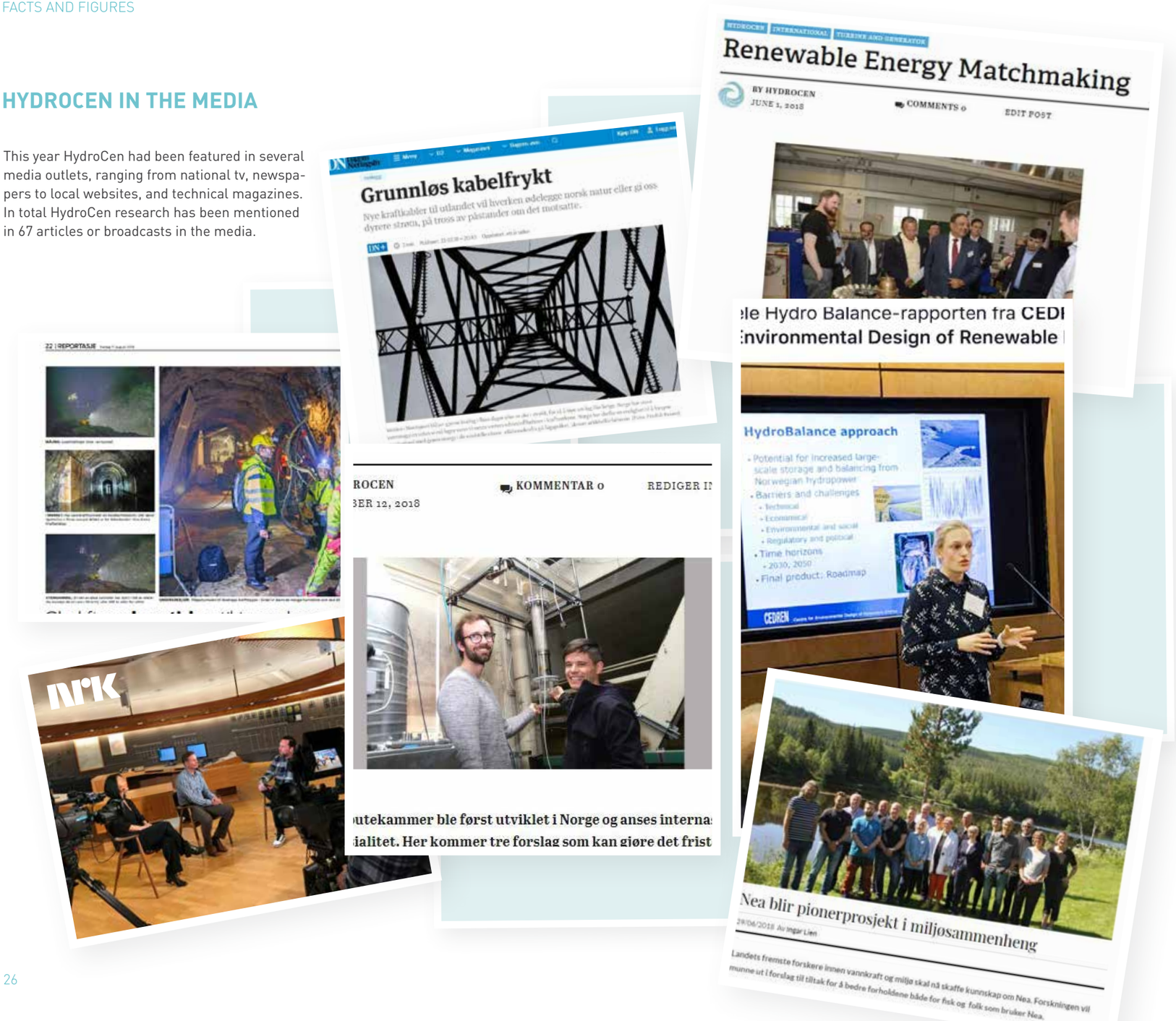
Together with clients and partners conduct practical research and improve and expand our portfolio of sediment handling solutions suitable for Norwegian projects, as well as to take part in meetings and workshops and be part of the Norwegian hydropower community.

What are your expectations for HydroCen looking forward?

To implement and conduct research on one of our solutions at a Norwegian powerplant

HYDROCEN IN THE MEDIA

This year HydroCen had been featured in several media outlets, ranging from national tv, newspapers to local websites, and technical magazines. In total HydroCen research has been mentioned in 67 articles or broadcasts in the media.



OUR OULETS

Newsletter:
Public newsletter, 4 publications, 204 subscribers and an opening ratio of 30-50%

Blog:
50 blog pieces with information and news from Hydrocen in 2018, more than 5000 visitors and 11 000 views.

Vannposten:
Weekly newsletter for researchers. 30 publications and 150 recipients.

Website:
Information and contact details for all projects and researchers in HydroCen. Publications and innovations are also accessible from www.hydrocen.com

SOCIAL MEDIA

Twitter:
147 tweets, 10 000 views per month and 387 followers.

10000

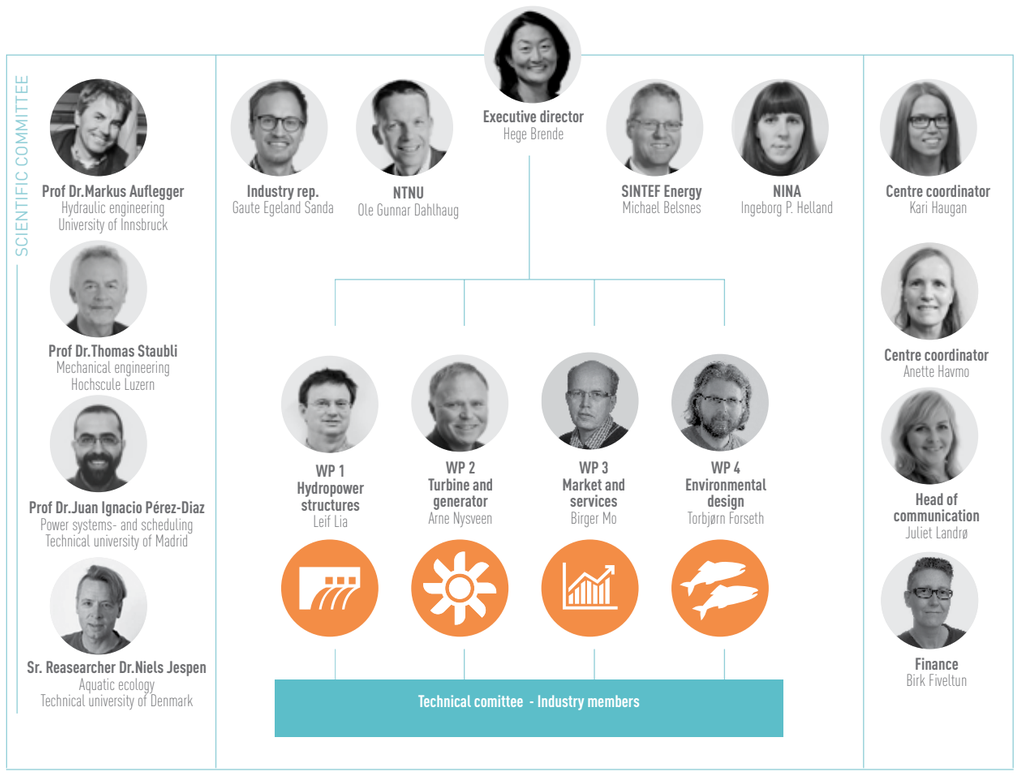
Facebook:
348 followers and an average post reach of about 3000

348

LinkedIn:
171 and increased activity

171 +

ORGANISATION



Executive Management Team and Admnistration		
Name	Institution	Function
Hege Brende	NTNU	Executive director
Ole Gunnar Dahlhaug	NTNU	Member
Ingeborg Helland	NINA	Member
Michael Belsnes	SINTEF Energi	Member

Name	Institution	Function
Gaute Egeland Sanda	Hydro	Member
Kari Haugan/Anette Havmo	NTNU	Secretary
Juliet Landrø	NTNU	Head of communications
Birk Fiveltun	NTNU	Finance

Researchers		
Name	Institution	Main research area
Roger Olsson	NGI	Hydropower structures
Ana Teixeira da Silva	NINA	Environmental design
Anders Foldvik	NINA	Environmental design
Audun Ruud	NINA	Environmental design
Berit Köhler	NINA	Environmental design
David Barton	NINA	Marked and services
Frode Fossøy	NINA	Environmental design
Ingeborg Palm Helland	NINA	Environmental design
Ingebrigt Uglem	NINA	Environmental design
Karl Øystein Gjelland	NINA	Environmental design
Line Sundt-Hansen	NINA	Environmental design
Margrete Skår	NINA	Environmental design
Richard Hedger	NINA	Environmental design
Terje Bongard	NINA	Environmental design
Torbjørn Forseth	NINA	Environmental design
Øystein Aas	NINA	Environmental design
Arne Nysveen	NTNU	Turbine and generators
Bjørn Nilsen	NTNU	Hydropower structures
Fjóla G. Sigtryggsdóttir	NTNU	Hydropower structures
Jochen Aberle	NTNU	Turbine and generators
Jonas Kristiansen Nøland	NTNU	Hydropower structures
Kaspar Vereide	NTNU	Hydropower structures
Kjetil Uhlen	NTNU	Turbine and generators
Knut Alfredsen	NTNU	Environmental design
Krishna Panthi	NTNU	Hydropower structures
Leif Lia	NTNU	Hydropower structures
Magnus Korpås	NTNU	Marked and services
Nils Reidar Bøe Olsen	NTNU	Marked and services
Nils Ruther	NTNU	Hydropower structures
Ole Gunnar Dahlhaug	NTNU	Turbine and generators

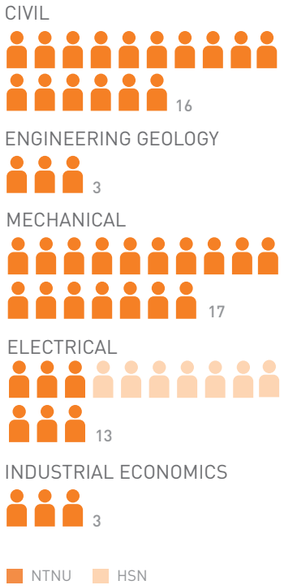
Name	Institution	Main research area
Pål-Tore Storli	NTNU	Turbine and generators
Roy Nilsen	NTNU	Turbine and generators
Stein-Erik Fleten	NTNU	Marked and services
Tor Haakon Bakken	NTNU	Marked and services
Torbjørn Nielsen	NTNU	Turbine and generators
Arild Helseth	SINTEF	Marked and services
Arnt Ove Eggen	SINTEF	Marked and services
Atle Harby	SINTEF	Environmental design
Atsede G. Endegnanew	SINTEF	Turbine and generators
Bendik Torp Hansen	SINTEF	Marked and services
Birger Mo	SINTEF	Marked and services
Christan Øyn Naversen	SINTEF	Marked and services
Eivind Solvang	SINTEF	Turbine and generators
Espen Eberg	SINTEF	Turbine and generators
Hans Petter Fjeldstad	SINTEF	Environmental design
Henrik Enoksen	SINTEF	Turbine and generators
Ingeborg Graabak	SINTEF	Marked and services
Julie Charmasson	SINTEF	Environmental design
Karl Merz	SINTEF	Turbine and generators
Lennart Schönfelder	SINTEF	Environmental design
Linn Emelie Schaffer	SINTEF	Marked and services
Michael Belsnes	SINTEF	Marked and services
Olve Mo	SINTEF	Marked and services
Peggy Zinke	SINTEF	Environmental design
Per Eilif Wahl	SINTEF	Marked and services
Sverre Hvidsten	SINTEF	Marked and services
Tarjei Kristiansen	SINTEF	Marked and services
Thomas Welte	SINTEF	Marked and services
Bernt Lie	USN	Turbine and generators
Gunne Hegglid	USN	Turbine and generators

Board		
Name	Institution	Function
Ivar Arne Børset	Statkraft	Chairman of the board
Norunn Myklebust	NINA	Board member
Knut Samdal	SINTEF Energi	Board member
Eivind Heløe	EnergiNorge	Board member
Rune Flatby	NVE	Board member
Erik Skorve	BKK	Board member
Alf-Inge Berget	E-CO	Board member
Ole Morten Midtgård	NTNU	Board member
Hege Brende	NTNU	Executive director/Board secretary
Kari Haugan/ Anette Havmo	NTNU	Secretary

Name	Institution	Function
Harald Rikheim	Forskningsrådet	Observer
Juliet Landrø	NINA	Observer / Head of communications
Jane Berit Solvi	Skagerak	1. deputy board member
Tormod Eggan	TrønderEnergi	2. deputy board member
Bjørn Honningsvåg	Lyse	3. deputy board member
Lars Grøttå	NVE	Deputy board member
Terese Løvås	NTNU	Deputy board member
Petter Støa	Sintef Energi	Deputy board member
Jon Museth	NINA	Deputy board member

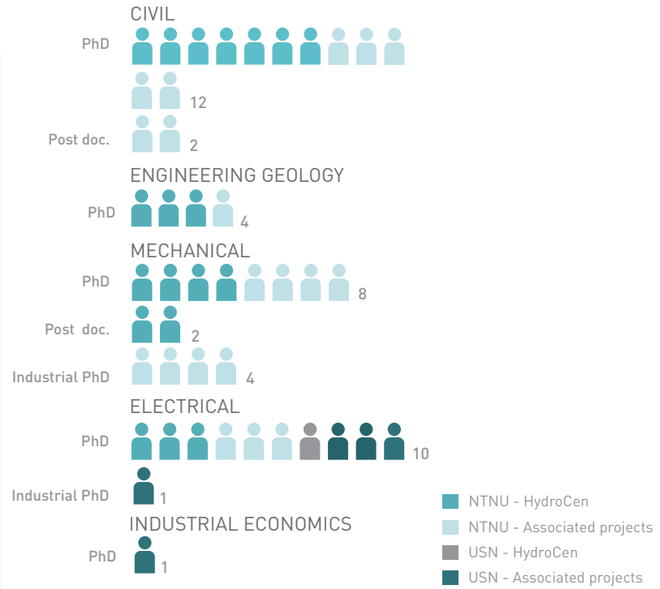
MASTER STUDENTS

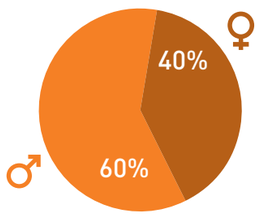
In 2018 we had a total of 52 master students at NTNU and The University of South-Eastern Norway (USN) within the field of hydropower. The distribution between the disciplines Civil, Mechanical, Electrical, Industrial Economics and and Engineering Geology is shown in the figure below.



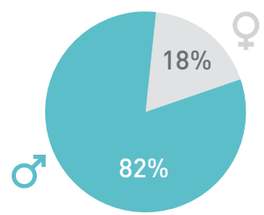
PHD AND POST DOCS.

In 2018 a total of 44 PhD and Post doc. where working within Civil, Mechanical, Electrical, Economy, and Engineering Geology.

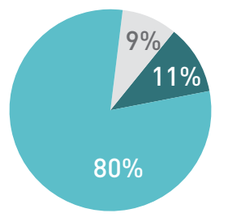




Gender distribution



Gender distribution



Distribution between PhD, Post doc. and industrial-PhD

PhD and Post doc. in HydroCen, employed in 2018

Name	PhD Post doc.	Gender	Nationality	Topic	Period
Raghbendra Tiwari	PhD	M	Napalese	Frequency converter solutions and control methods for Variable Speed reversible pump-turbine system	2018-2020
Tor Inge Reigstad	PhD	M	Norwegian	Grid Integration of Variable Speed Hydro Power Plant	2018-2021
Shohreh Monshizadeh	PhD	F	Iranian	The Flexible Hydro Power Unit	2018-2020
Halvor Kjærås	PhD	M	Norwegian	Modelling of fish guidance by floating devices	2018-2021
Nirmal Acharya	PhD	M	Nepalese	Design of a Francis turbine that accomodates high sediment concentration	2018-2021
Bjørn Winther Solemslie	Post Doc.	M	Norwegian	Resonance and pressure pulsations in High Head Francis Runners	2018-2020
Hossein Ehya	PhD	M	Iranian	Electromagnetic analysis and on-line fault detection in hydropower generators	2018-2021

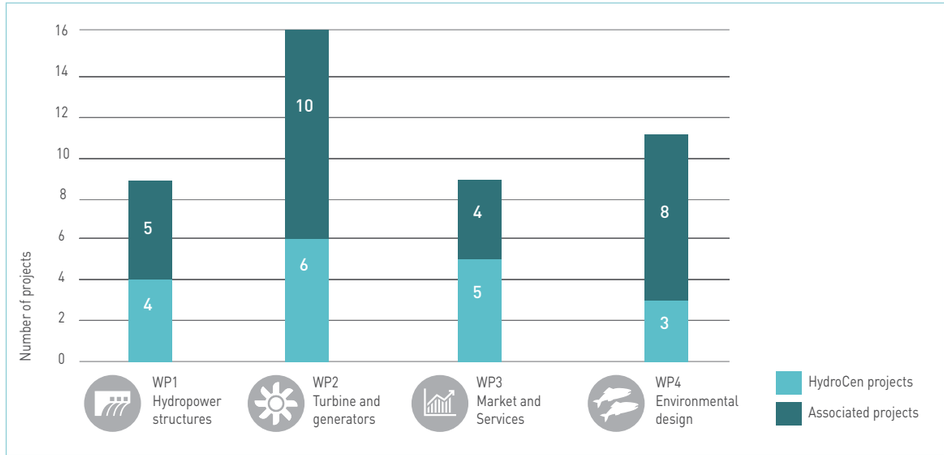
FINANCIAL STATEMENT HYDROCEN 2018

All figures in 1000 NOK

Funding	**Funding**	**In-kind**	**Total**
The Research Council of Norway	23,734		23,734
Industry partners	9,535	4,735	14,270
Research partners		17,635	17,635
Total funding 2018	33,269	22,370	55,639
Revenue 2018	**Funding**	**In-kind**	**Total**
Sintef Energi	13,727	5,032	18,759
NINA	4,944	2,685	7,629
NGI		271	271
USN	806	376	1,182
NTNU	13,792	9,271	23,063
Industry partners in-kind		4,735	4,735
Total Costs 2018	**33,269**	**22,370**	**55,639**

PROJECTS OVERVIEW 2018

A total of 45 projects related to hydropower were ongoing in 2018. 27 of these are associated projects within hydropower where HydroCen' s researchers are involved.



HydroCen Projects		
Project name	Project leader	Field of study
1.1 Tunnels, penstocks and surge chambers	Bjørn Nilsen	Hydropower structures
1.2 Dam construction and dam saftey	Fjola G. Sigtryggsdottir	Hydropower structures
1.3 Sediment handling	Nils Rüther	Hydropower structures
1.4 Fish friendly intakes	Leif Lia	Hydropower structures
2.1 Variable speed operation	Arne Nysveen	Turbine and generators
2.2 Fatigue loads on turbines	Torbjørn Nielsen	Turbine and generators
2.3 Pumpe turbines in existing power plants	Pål-Tore Storli	Turbine and generators
2.4 Turbine and generator lifetime	Thomas Welte	Turbine and generators
2.5 Flexible Hydropower Unit	Kjetil Uhlen	Turbine and generators
2.6 New Design of guide vanes	Pål-Tore Storli	Turbine and generators
3.1 Future market structures and prices	Birger Mo	Market and services
3.2 Remaining useful life, failure probability	Arnt Ove Eggen	Market and services
3.3 Optimal hydro design in the future power system	Birger Mo	Market and services
3.4 Environmental constraints and uncertainties – impact on revenues	Arild Helseth	Market and services
3.5 Water resources assessment	Tor Haakon Bakken	Market and services
4.1 Governance and social acceptance	Audun Ruud	Environmental design
4.2 Fish migration	Ana da Silva/ Torbjørn Forseth	Environmental design
4.3 Multiple interests under future flexible hydropower operation	Atle Harby	Environmental design

Associated Projects				
Project name	Project leader	Field of study	Type	Project owner
HiFrancis FSI Toolkit	Martin Holst	Turbine and generators	IPN	EDRMedeso
FlomQ	Nils Rüther	Hydropower Structures	IPN	Energi Norge
MonitorX	Thomas Welte	Turbine and generators	IPN	Energi Norge
EnergizeNepal	Nawaraj Sanjel	Turbine and generators	MFA	Kathmandu University
FIThydro	Peter Rutschmann	Environmental design	EU H2020	Koordinator Technical University of Munich, Germany
Elvemuslingens miljøkrav	Bjørn M. Larsen	Environmental design	Government	NINA
HYCANOR	Ingeborg Palm Helland	Environmental design	INTPART	NINA
Miljødesign Mandalselva	Torbjørn Forseth	Environmental design	Skattefunn/Industry	NINA
SafePASS	Torbjørn Forseth	Environmental design	KPN	NINA
Stable Dams	Bård Arntsen	Hydropower Structures	KPN	Norut
HydroFLEX	Ole Gunnar Dahlhaug	Turbine and generators	EU H2020	NTNU
Fancis -99	Chirag Trivedi	Turbine and generators	Intern	NTNU
SediPASS	Nils Rüther	Hydropower Structures	KPN	NTNU (NVKS)
TunnelRoughness	Jochen Aberle	Hydropower Structures	KPN	NTNU (NVKS)
HydroStator	Arne Nysveen	Turbine and generators	KPN	NTNU (NVKS)
HiFrancis KPN	Ole Gunnar Dahlhaug	Turbine and generators	KPN	NTNU (NVKS)
Reversible pumpeturbiner	Torbjørn K. Nielsen	Turbine and generators	PhD	NTNU (NVKS)
Levetidsberegning for Francis	Petter Østby	Turbine and generators	IPN	Rainpower
HydroBalance	Michael Belsnes	Market and services	KPN	SINTEF Energi
IBM	Arild Helseth	Market and services	KPN	SINTEF Energi
MultiSHARM	Marte Fodstad	Market and services	KPN	SINTEF Energi
PRIBAS	Arild Helseth	Market and services	KPN	SINTEF Energi
SusWater	Atle Harby	Environmental design	KPN	SINTEF Energi
Fleksibel Sandfang (FlexS)	Kaspar Vereide	Hydropower Structures	Industry	Sira Kvina Kraftselskap
Miljødesignhåndbok for ørret i magasin	Ingeborg Palm Helland	Environmental design	Government	Miljødirektoratet
Fransed	Ole Gunnar Dahlhaug	Turbine and generators	International Cooperation	NTNU
HyMo	Atle Harby	Environmental design	Government	Miljødirektoratet

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NTNU

TECHNICAL COMMITTEES 2018

WP 1 Hydropower stuctures	WP2 Turbine and generator	WP3 Market and services	WP4 Environmental design
Leif Lia, NTNU (leader)	Arne Nysveen, NTNU (leader)	Birger Mo, SINTEF Energy (leader)	Torbjørn Forseth, NINA (leader)
Magne Skog, Agder Energi Vannkraft	Tore Johan Flåm, NTE	Bjørn Austrud, Agder Energi	Svein Haugland, Agder Energi Vannkraft
Per Vidar Halsnes, BKK	Øyvind Linnebo, ABB	Tarald Espeland, BKK	Ingvill Stenseth, BKK
Eve C. Walseth, Energi Norge	Inge Lines, Agder Energi Vannkraft	Vidar Hansen, E-CO Energi AS	Bjørn Otto Dønnum, E-CO Energi AS
Helge Martinsen , Glitre Energi Produksjon	Sverre Dahl Knutsen , E-CO Energi AS	Christian Oshaug, NTE	Geir Taugbøl, EnergiNorge
Kaspar Vereide, Sira-Kvina	Martin Aasved Holst, EDR Medeso	Eirik Veirød Øyslebø, NVE	Trygve Øderud , Glitre Energi Produksjon
Magne Wraa, Skagerak Energi	Tormod Kleppa, Eidsiva Vannkraft	Jakop Bjelland, SKL	Stein Øvstebø, Hydro
Tore Okkenhaug, SKS	Iren Aanonsen, Energi Norge	Atle Frøland, Tafjord	Trond Erik Børresen, Lyse Produksjon AS
Siri Stokseth, Statkraft	Line Drange Ruud, Glitre Energi Produksjon	Frode Vassenden, TrønderEnergi Kraft AS	Roy M. Langåker, Miljødirektoratet
Anne Marit Håstein Ruud, Statkraft	Lars Lone, Hydro Energi AS	Sven Per Lønne, Glitre Energi Produksjon	Jo Halvard Halleraker, Miljødirektoratet
Oddmund Brevik , E-CO Energi AS	Valentin Koestler, NVE	Hans Ole Riddervold, Hydro	Eirik Bjørkhaug, NVE
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