ANNUAL REPORT

2011

CEDREN Centre for Environmental Design of Renewable Energy

CENTRE FOR ENVIRONMENT-FRIENDLY ENERGY RESEARCH

CEDREN – Centre for Environmental Design of Renewable Energy: Research for technical and environmental development of hydro power, wind power, power line rights-of-way and implementation of environment and energy policy.

SINTEF Energy Research, the Norwegian Institute for Nature Research (NINA) and the Norwegian University of Science and Technology (NTNU) are the main research partners. A number of energy companies, Norwegian and international R&D institutes and universities are partners in the project.

The centre, which is funded by The Research Council of Norway and energy companies, is one of eleven of the scheme Centre for Environment-friendly Energy Research (FME). The FME scheme consists of time-limited research centres which conduct concentrated, focused and long-term research of high international quality in order to solve specific challenges in the field of renewable energy and the environment.

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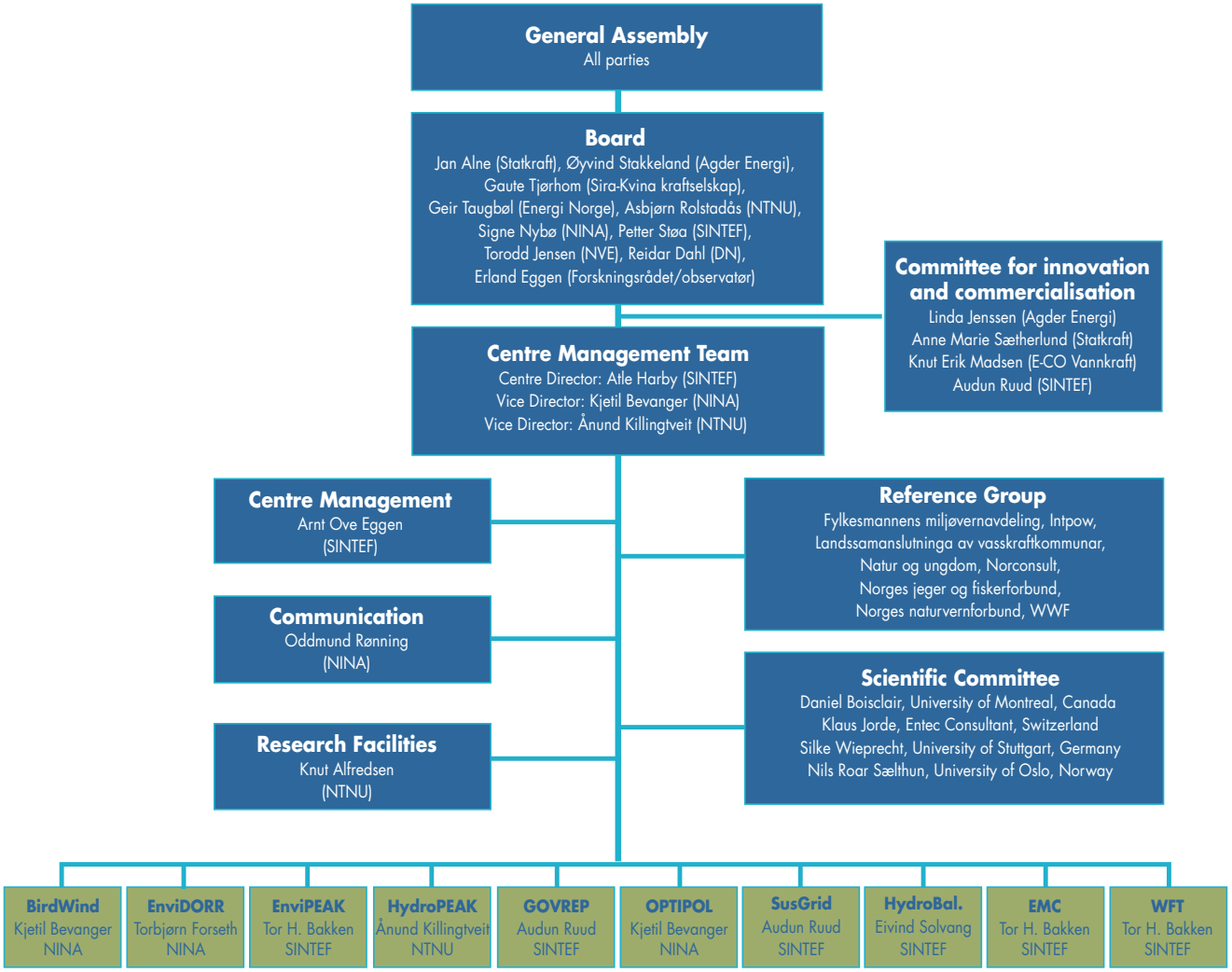
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CEDREN in 2011

The main objective of CEDREN is to develop and communicate design solutions for renewable energy production that address environmental and societal challenges at local, regional, national and global levels. The research is focused on hydro and wind power production and power transmission systems. CEDREN is an interdisciplinary research centre, building integrated knowledge from the technical, environmental and social science into better policies and solutions.

Environmental design means that planning, building and operation have to include technical, economic, environmental and social aspects from the beginning. This is the only way to develop future hydropower plants, wind farms and transmission lines in a sustainable manner. All CEDREN activities are concentrated around this task, providing knowledge for better decision-making and reduced uncertainties.

The CEDREN consortium represents a unique compilation of institutions with internationally recognised competence on hydropower design, hydrology and hydraulics, applied aquatic and terrestrial ecology and social and economic sciences. Through CEDREN, scientists, industry and management finds a common site for development of future environmental friendly energy. The multi-dimensional combination and outcome of different scientific disciplines and close cooperation with end users is enhanced within the frame of a research centre. The organisation of CEDREN is shaped for this purpose.

CEDREN has noticed a rapidly growing interest from the energy industry, authorities, the scientific community and the broader public in 2011. CEDREN was quoted or referred to in about 300 articles in public media during 2011, ranging from small local newspaper articles to international TV programs. During 2011, CEDREN participated in more than 50 national and international meetings, workshops, seminars and conferences. CEDREN also organised more than 40 meetings among user groups and consortium partners. Through this activity, CEDREN disseminates findings and results to a wide range of users – and we receive crucial feedback and guidance for future research directions.

Even though CEDREN has focused most of the activity within Norway, we have also been very active on the international arena. We are collaborating with top international scientists, and we have taken part in a series of scientific conferences and seminars in 2011, where our own Conference on Wind Energy and Wildlife Impacts was one of the highlights. CEDREN has also organised or participated in targeted workshops and meetings in India, Malaysia, Germany, UK, Tanzania, Slovenia, Croatia and Georgia in 2011.

Research in CEDREN covers both detailed studies of specific topics and broader overview analysis. For many of the detailed studies, the use of MSc, PhD and post doc students are important. We have noticed an increased interest in CEDREN topics among students, and we believe this is due to the centre status.

CEDREN is educating many PhD and post doc students which are focusing on specific research topics in their daily work. It is important that these clever minds also have opportunities to meet and discuss across disciplines and traditional subjects. CEDREN organizes targeted workshops and meetings for our students, and this picture is taken during a PhD-excursion visiting Smøla wind park, Follsjø and Gråsjø hydro reservoirs and the regulated rivers Surna and Orkla. Photo: Ånund Killingtveit, NTNU

We find that the research centre concept is very well suited to be the core of research and education on one side and the dissemination and dialogue to industry, authorities, stakeholders and decision makers on the other side. Please enjoy the highlights of research from CEDREN 2011 in the following pages!

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CEDREN projects

The CEDREN research is currently conducted through eight different projects – mainly of four years duration. The projects cover the multiplicity of hydro power, wind power, powerlines and governance – through research within technology, biology and social science.

Two of the projects were already started when CEDREN was established in 2009. Both in 2011 and in 2012, new CEDREN projects were started with funding from the Research Council and the Energy Industry. CEDREN will continue to develop research goals and start new projects also in the coming years.

		Duration	Finances	Project manager
BirdWind	Bird friendly localization and design of new onshore wind power plants. Pre- and post-construction studies of conflicts between birds and wind turbines in coastal Norway.	2007-2011	23 mill NOK	Kjetil Bevanger
EnviDORR	Increased power and salmon production. Environmentally designed operation of regulated rivers.	2007-2011	25 mill NOK	Torbjørn Forseth
EnviPEAK	Effects of rapid and frequent flow changes in regulated rivers. Studies on environmental impacts of hydropeaking and guidelines for mitigation measures.	2009-2013	37 mill NOK	Tor Haakon Bakken
HydroPEAK	Future hydropower design. Studies on hydropower development for peaking and load balancing.	2009-2014	37 mill NOK	Ånund Killingtveit
GOVREP	How to combine environmental and energy policy concerns. Governance for renewable electricity production	2009-2013	15 mill NOK	Audun Ruud
OPTIPOL	Optimal design and routing of power lines. In ecological, technical and economic perspectives.	2009-2013	18 mill NOK	Kjetil Bevanger
SusGrid	Sustainable Grid Development. Improving planning tools, and governance procedures facilitating public acceptance and consensual realization of grid projects.	2011-2014	17,5 mill NOK	Audun Ruud
EcoManage	Improved development and management of energy and water resources. Perspectives on energy payback ratio; water consumption in hydro power plants; and ecosystem services in regulated rivers.	2012-2015	13 mill NOK	Tor Haakon Bakken

High quality equipment and laboratories are necessary to be able to perform high quality research. CEDREN have received funding from The Research Council of Norway to laboratories and field equipment, and is now able to offer modern research facilities to students and scientists. Some of the field equipment for physical and biological studies in regulated rivers was demonstrated in River Nidelva in Trondheim for the state secretary and delegates from the Norwegian Ministry of Petroleum and Energy. The demonstration also allowed for a fruitful discussion and dialogue between CEDREN researchers and the authorities. Photo: Oddmund Rønning, NINA

Easing the conflict between wind energy and birds

With the proliferation of wind energy in the years ahead there will be a growing need for new knowledge and effective measures to protect birds and other wildlife. CEDREN is contributing with thoroughly researched methods for mapping the movement patterns of birds in time and space.

CEDREN's BirdWind project has given a boost to the quality of international research on how vulnerable specific bird species are to collisions with wind turbines. The project has developed and refined three different monitoring methods by studying the impact of Statkraft's Smøla wind-power plant on avian life: effective use of avian radar, specially trained dogs, and satellite telemetry using GPS-tagging of white-tailed eagles.

Birds detected by radar ■ CEDREN researchers have developed automated protocols to handle the vast amounts of data collected from the project's radar system, and developed good filtering methods for recognising birds and flocks. Project manager Kjetil Bevanger, Senior Research Scientist at the Norwegian Institute for Nature Research (NINA), believes the island of Smøla on the coast of western Norway is actually well-suited as the location for a wind-power plant, despite the fact that turbine blades have killed substantial numbers of birds – including white-tailed eagles (once near extinction but now recovering steadily) and a species of willow ptarmigan found only on Smøla. "We have not yet determined whether these deaths affect the overall population in the long run, but we will know once the final data are processed in connection with the Ph.D. study conducted by Espen Lie Dahl. When more data are collected and we have more precisely identified the parameters for high risk of collision, it may be possible to reduce the loss of some individuals by adjusting the operating times of a few turbines."

New avian radar ■ The Research Council of Norway awarded CEDREN an extra grant for infrastructure to purchase a new and improved avian radar from The Netherlands. The new radar, combined with methodological development, will provide important insight into the environmentally sound placement of wind turbines and power lines.

Bevanger praises the project's cooperation with SINTEF and in particular Research Scientist Yngve Steinheim. The internationally recognized radar team comprises Norway's foremost experts on avian radars. "Much of what was previously published about using avian radar in research was of poor quality. Cooperation between radar technologists such as Steinheim and NINA's radar ornithologist Roel May enhances our capabilities for finding solutions to avian impacts. The radar team puts a great deal of effort into evaluating and verifying which information is reliable," Bevanger explains.

In March 2008 the BirdWind Project started to collect bird data on Smøla using the Merlin radar system at the picture. The experience acquired by the radar ornithologists is crucial also for the operation of a new car mounted 3D radar system. Photo: Kjetil Bevanger, NINA

The BirdWind researchers tested and calibrated the radar using a model airplane that was roughly the size of a white-tailed eagle and manoeuvred to mimic its flight. A German research project hired BirdWind's model airplane and pilot to calibrate its own radar as well.

Searching and tagging ■ Other measures successfully developed in the project include a method to find dead birds and GPS tagging of eagles. The researchers found that specially trained dogs were helpful in tracking down birds killed by turbine blades. In addition, some 60 white-tailed eagles were fitted with GPS devices and have supplied up to four years' data on their movement patterns. It turns out the eagles roam great lengths of the Norwegian coastline throughout the year, as far north as North Cape.

Concluding conference ■ The BirdWind project was concluded with the Conference on Wind Energy and Wildlife Impacts (CWW2011) in Trondheim in May. "The conference was the first of its kind in the world and was a success," says Bevanger. Roughly 300 participants from 30 countries exchanged knowledge about the latest findings from international research on relevant topics. CEDREN scientists will be involved in the planning of a follow-up conference in Sweden in 2013 and Germany 2014.

More salmon and **more** power

It is entirely possible to design hydropower plants and the operation of regulated rivers to maximise electricity output as well as increase salmon populations.

The recently completed EnviDORR project has made some important findings. Biologists and hydrologists have collaborated with the energy industry on developing effective and environment-friendly methods of regulating rivers that are home to viable salmon populations.

"We've had a good dialogue with the energy industry. The companies have shown real interest, even those not directly involved in this project," says Torbjørn Forseth, Senior Research Scientist at the Norwegian Institute for Nature Research (NINA) and project manager of EnviDORR.

Water when needed ■ One of the ways to ensure that more salmon fry survive is to match water discharge during spawning to discharge during the winter. This has been successfully implemented in Norway's Bjoreio River, where fish previously had been "fooled" into spawning in areas that were dewatered during winter. Another measure is to enhance salmon spawning grounds by adding gravel in permanently water covered areas.

In 2009 the EnviDORR project constructed the country's first experimental salmon ladder along the Nidelva River in southern Norway. Fish often have difficulty finding salmon ladders (designed to help them to bypass a dam when swimming upstream), so the project researchers experimented with how to help fish to find their way into the ladder. Different entrance angles were tested, along with different types of outlets from the lowest pool into the river, as well as an outlet that sprays additional water onto the surface downstream to attract fishes' attention. There are plans to establish a competence centre on fish migration at the Norwegian University of Science and Technology (NTNU).

The EnviDORR project also carried out studies of how climate change may affect power production and salmon populations. Several climate scenarios indicate that both will increase in this century due to increased water flow.

Weirs as migration obstacles ■ One doctoral degree research project has studied the impact of artificial weirs that can both hinder migration and reduce fish production. Studies along the Nidelva River in Aust-Agder have found that salmon have multiplied dramatically since the weirs were removed four years ago, and that fish can migrate far more quickly.

Two other doctoral studies have provided important new insights related to habitat conditions, such as how much water is sufficient for salmon, and the environmental needs of the youngest fish.

Strong research position ■ Norway is a leader in research on salmonid fish, yet research on salmon and inland fish has been fragmented and mostly limited to individual rivers. The EnviDORR project has brought together research groups, with an integral approach that is independent of location.

"Another unique feature of our project is the close co-operation with the energy industry. We see it as a mutual

Female salmon are selective when choosing where to spawn. Researchers in the EnviDORR project have discovered ways to enhance reproductive conditions for salmon – such as adding gravel to their spawning grounds. Photo: Helge Skoglund, Uni Environment

learning opportunity. The energy companies learn about biology and we have learned about the framework within which they operate. Now we speak the same language," says Forseth.

He sees great potential for utilising the findings from the EnviDORR project when revising concession terms, which are primarily designed to improve environmental conditions in regulated rivers. Leading up to 2022 there are some 400 concessions that may be subject to revision if requested by public interests.

Saving eagle owls

The CEDREN project OPTIPOL has set out to prevent some of the problems that arise between large birds and power lines. A simple perch can save the endangered eagle owl from electrocution. The project will also provide greater insight into the impact of collision with power lines on the population of capercaillie and black grouse.

An alarmingly high number of eagle owls are electrocuted each year as they attempt to land on power-line poles in the distribution grid. Listed as endangered in Norway, the eagle owl has a wingspan large enough to easily cause a short-circuit between phase conductors and the earth conductor in the poles, resulting in electrocution and certain death for the bird.

Harmless to equipment ■ Bird deaths can be greatly reduced by mounting elevated perches on the crossbars located at the top of power-line poles in the grid. "Another approach to the problem could be to cover the power lines where they are attached to the poles, but this may lead to an increase in corrosion on the lines in coastal areas," says Steinar Refsnæs, research scientist at SINTEF Energy Research.

At the Rødøy-Lurøy power plant in Nordland, researchers have installed elevated perches on selected power-line poles. The perches extend from the ends of the crossbars. Elements with barbs have also been installed between the pin insulators on the crossbar to deter the eagle owl from landing where it may be electrocuted.

The risk of a power outage is a serious issue for power grid operators. There may not be many outages each year, but a short-circuiting event creates a lot of noise on the line even when an outage is avoided. Many types of electrical equipment in homes and businesses are sensitive to noise on the grid.

The perch has attracted considerable attention both in the media and at various scientific conferences. It was also featured at a side event hosted by CEDREN during the Conference of the Parties to the Bonn Convention in Bergen last autumn.

Gallinaceous birds ■ The researchers participating in the OPTIPOL project are also gaining significant insight into how gallinaceous birds interact with power lines. It is well known that many ptarmigan, capercaillie, and black grouse are killed when they collide with power lines. What is not known, however, is whether this extra mortality may have a negative impact on the overall bird population. In order to find an answer, researchers must first obtain a full overview of the capercaillie and black grouse populations in a large area.

A population assessment is being carried out over an area of 30 square kilometres in Ogndal, Nord-Trøndelag County. This is being done by identifying and counting flushed capercaillie and black grouse within an area surrounding a seven km long corridor of a 300 kV transmission line and just above two km on both sides. Bird droppings are also recorded, and by analysing DNA taken from the excrement it will be possible to estimate the population and

Eagle owls are frequently resting at the power line pole cross arms, exposing themselves for electrocution hazard. Photo: Frode Johansen

recognise if birds found dead beneath the power line come from the population. The corridor is regularly patrolled to find any birds killed by flying into the line. The project has bought and trained a dog to assist during the dead bird searches.

This is the first time such a thorough count has been carried out to determine the impact of collision with power lines on the bird population.

The area being covered is large and thus the data collection process is extensive. "This wouldn't have been possible if OPTIPOL wasn't a big project linked to CEDREN," emphasises project manager Kjetil Bevanger of NINA.

"Unfortunately, it is not just the autumn's 'excess' population that is lost to the power lines, but also adult birds in the spring. These are the individuals in a position to reproduce. Thus it cannot be ruled out that this mortality may have an effect on the population development."

Preventing damage to turbines and hydro-tunnels

Modern market operations have made some hydropower plants to practice hydropeaking with frequent sudden stops and restarts in hydropower production more often than its original design dictates. This can cause problems in the hydro-tunnels bringing water to the turbines.

Doctoral fellow Kari Bråtveit is studying what happens to waterways when production levels are adjusted. Her efforts are part of the CEDREN project HydroPEAK. One of the tasks she focuses on, is the sand trap associated with generator no. 5 at the Hydroelectric Power Station in Tonstad, Norway, operated by the Sira-Kvina power company.

"When you alter the level of production, you also change the hydraulics of the system. It's important to know the limits of the system before changing the production level," Bråtveit says.

Production rates at Norwegian hydropower plants follow market prices for energy. When the price goes down, the plants store water in their reservoirs and production is quickly downscaled by reducing or shutting down the flow of water through the turbine. Water already flowing down the hydro-tunnel will not cease flowing immediately, and a pressure wave is generated which moves back up the tunnel and then down again. The water will continue to oscillate in the tunnel before gradually being damped out.

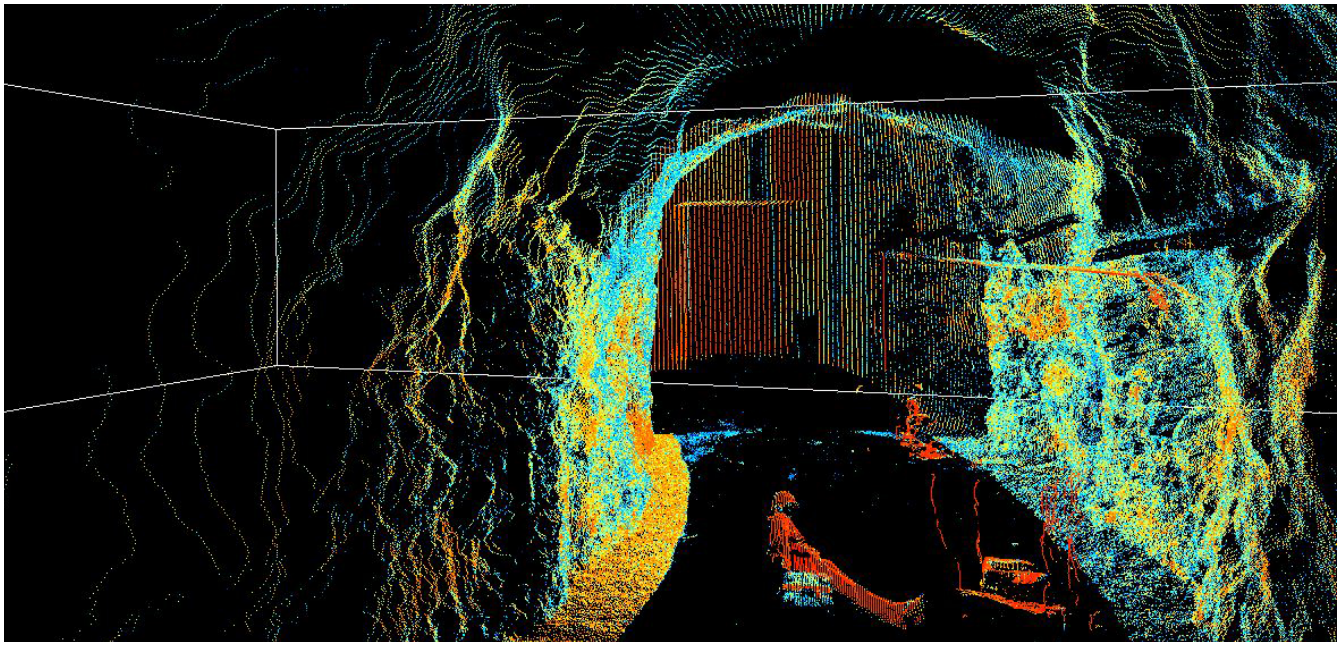
Rocks and gravel ■ "Many plants that have increased the frequency of hydropeaking have seen an increase in sediment load. Tonstad Hydroelectric Power Station has reported damage to turbine vanes and runners as a result of contact with sediment that exceeds a certain size," states Bråtveit.

An increase in pressure fluctuations caused by hydropeaking may also trigger downfalls of rocks that can block the tunnel.

At certain water intakes, especially in creeks, the water may contain trapped air which can then form air pockets in the tunnels. If strong fluctuations arise from frequent hydropeaking, the air pockets can be set in motion and lead to a powerful blowout.

Photographed on the inside ■ Before water from the reservoir enters the turbine it passes through a sand trap to prevent gravel, rocks and other foreign elements from reaching the turbine. Bråtveit and her colleagues have mapped the interior of the sand trap at Tonstad in detail, using a laser which scans 360 degrees around its axis. The data is entered into a model which simulates the effect of frequent, major changes in the flow of water on the flow pattern through the sand trap.

"The geometric shape of the sand trap is reconstructed using various computer programs prior to entering the calculations into a computational fluid dynamics (CFD) tool. By calculating turbulence and two-phase flow, we hope to



A high performance laser scanner was acquired to CEDREN through research facilities funding from the Research Council of Norway. The laser scanner has been used to scan the topography of river beds and also for investigating the surface of the sand trap at Tonstad power plant. Data are processed and used in model simulations to investigate impacts of new operational routines.

gain greater insight into the mechanisms arising from sudden adjustments in production level," Bråtveit states.

When operations resume in Tonstad, three new sensors will be in place inside the sand trap and the tunnel to provide researchers and the power plant operators with data on the velocity, discharge and depth of water during operations so that they can compare the model against actual conditions.

New insight is important ■ Discharge fluctuations and the transport of sand in waterways have posed a number of challenges for the Sira-Kvina power company.

"Today, power plants start and stop more often than in the 1980s and 1990s. We believe this trend will grow even more with the introduction of price differentiation for energy used during the day, at night or certain times of the day. This project is important if we are to learn more about what this entails," says Sira-Kvina's Production Manager, Arne Sæterdal.

Fish can **tolerate** hydropeaking

Fish withstand rapid fluctuations in river flow better than previously believed. By adapting how hydropower is operated on regulated rivers, it is possible to optimise energy production and protect river ecosystems.

The prevailing assumption is that the changes in water level resulting from hydropeaking (the practice of frequent sudden stops and restarts in hydropower production) are harmful to fish downstream, even though energy companies operate within legal regulating limits.

"The findings from studies we have carried out in Norway and Finland indicate that the issue is more complex than we originally thought," says Tor Haakon Bakken, project manager of EnviPEAK, a project under CEDREN.

Impact in summer ■ Professor Ole Kristian Berg of the Norwegian University of Science and Technology (NTNU) has been heading the experiments at Ims (Norway) and in Paltamo (Finland) since August 2010. In a controlled environment, his team exposed fish to stress in the form of fluctuations in flow rates and water levels, and compared the fish to a control group of fish that were not exposed to these rapid changes. The team analysed differences in the two groups' growth and general condition.

"In the winter it was not evident that the fish were particularly affected by hydropeaking," explains Professor Berg. "But in the summer we detected a certain effect, although it was milder than we had expected. This indicates that the authorities need to take seasonal factors into account when making recommendations for hydropower operations."

The professor emphasises that these are preliminary conclusions and that his team's laboratory findings must be verified with thorough studies conducted in actual regulated and unregulated rivers.

"Nevertheless, these laboratory findings give a very good indication of how fish experience external stressors. In our laboratory trials we control the environment in order to eliminate parameters that might bias the results."

"The winter results in particular are uncertain. The fish have such a low metabolic rate – nearly going into a state of hibernation – that it is very difficult to determine the precise impacts of hydropeaking."

Stranded on land ■ Tor Haakon Bakken points out that there are many factors that go into assessing the potential impact of increased hydropeaking. One of these is the stranding of fish, which was not studied in the Finland trials where no fish was stranded. It is known from previous research carried out in Norway and abroad that fish and other organisms living in a regulated river can become trapped in small pools or stranded on dry ground.

"Too little is known, however, about the proportion of stranded fish that survive, why some survive and others die, and on long-term effects of those who survive," says project manager Bakken. "There are certain rules from previous experiments, but these are based on a limited set of experiments and they don't encompass the diversity of rivers or the type of regulation or fish population."

Research scientist Håkon Sundt from SINTEF carries out detailed measurements of the riverbed profile and water flow conditions. Together with laboratory experiments and numerical modeling studies, these field campaigns provide new knowledge on how hydropeaking affects fish and other living organisms in the rivers. Photo: Julian Sauterleute, SINTEF

Other conditions affected ■ Bakken underlines the fact that hydropeaking has an impact on other environmental conditions in a river. The composition of the riverbed substrate is an important factor determining the physical habitat quality for river organisms. Fish and bottom-dwelling organisms require certain riverbed characteristics and water-flow conditions during their various life stages, including spawning.

"A certain river flow is essential when spawning is taking place to ensure that the eggs are not left dry when the water level declines. We must not lead the fish into spawning in areas that will go dry when the water flow is reduced due to changes in the electricity production."

Other factors also have an impact on river ecosystems, such as variations in water temperature, food supply and competition between individuals. Regulation can affect some but not all of these factors, concludes Bakken.

Norwegian hydro storage for **Europe**

Exploiting large scale Norwegian hydro storage to balance Europe's growing wind-power generation could create significant value in Norway as well as provide climate benefits.

It is possible to develop 20 000 MW of new balancing power capacity by constructing new power plants between existing Norwegian hydro reservoirs. This can be used to store energy as water when there is too much wind and solar energy in Europe, and to produce hydropower when the wind is no longer blowing.

This is one of the findings in the CEDREN project HydroBalance.

Climate mitigating industry opportunities ■ "This topic is extremely interesting, because it deals with a potential source of significant value creation in Norway," says Atle Harby, Director of CEDREN.

"Exploiting this would give Europe more renewable energy. European countries can use hydropower from Norway when there is not enough wind power. It also opens the possibility of using wind energy that would otherwise be lost.The water could be pumped back into the reservoirs when there is excess wind energy, a situation that has already occurred several times – and will happen often in the future. This strategy could make an important Norwegian contribution to reducing CO_2 emissions," says Harby.

Case Studies ■ CEDREN has done a pilot study of 12 existing hydropower reservoirs in southern Norway, assuming that Norway would build new power stations and tunnels parallel to the existing generating plants at these reservoirs.

The new plants will not interfere with current power generation, and reversible turbines will be installed in seven of them.

Matching requirements ■ "Our study shows that Norway can provide balancing power for a week or two without compromising regulation permits. We can expect future wind production from The North Sea Area to vary a lot, and it may stop blowing for a week or two," says Harby.

Water levels in the reservoirs will change more often and also more rapidly when used for balancing power services than under normal conditions. According to Harby, more research on environmental impacts in reservoirs, and possible mitigation measures are needed

Value creation and CO_2 cuts ■ "Why would supplying balancing power be such good business for Norway?"

"The power we export while Europe cannot produce enough themselves, will give us so much more in hard cash than we have to pay to pump water back up into the reservoirs."

CEDREN has studied 12 new hydropower plants with a capacity of 11 500 MW in the pilot project. The study also estimates that it is technically possible to build balancing power plants in Norway with a total capacity of 20 000 MW.

"Germany wants a generating capacity of 60 000 MW to balance the natural fluctuations in future solar and wind power production. We cannot meet all of this with Norwegian hydropower alone, but we can cover a part of it. However, Germany is not the only potential partner. We

Norwegian hydro reservoirs have 90 TWh of storage capacity and can use parts of this for balancing European renewable energy. Photo: Atle Harby, SINTEF

can expect similar balancing needs with the UK and other European countries too," says Harby.

Costs ■ Each of the largest balancing power plants that CEDREN's scientists have put into their computer models will require two underwater cables, using current cable technology," according to Harby.

"Won't the total investment required make the electricity too expensive?"

"No, we believe that this would be the cheapest way to balance wind power, although it would require international cooperation regarding new markets and regulations. Quite the contrary; it could bring significant revenues to local communities, municipalities, counties and the state."

A new power line rebellion? ■ All power plants in the pilot study lie close to the coast. They will not create a need for long new overhead power lines. But Harby makes it clear that the development of balancing power plants will need more power lines and necessitate strengthening the central grid.

"This is a challenge in the Norwegian environmental debate. Increased use of renewable energy creates the need for power lines. Without lines we can transmit neither fossil nor green electricity. But when we have more knowledge we will have to try to create good environmental solutions – at both global and local level!"

Avoidable conflicts over **power lines**

Conflicts often arise when new power lines are planned and constructed. Studies carried out by CEDREN researchers, however, show that such disagreements can be avoided.

The SusGrid project examines the underlying components of conflicts that often develop around major projects for electricity production and power transmission lines. A new study under the SusGrid project cites the lack of a clear political foundation for grid expansion as one source of such conflict. This can lead to less efficient concession processes and higher levels of discord. At the same time, the public understands the need for new transmission lines and considers Statnett a trustworthy developer.

Political platform is lacking ■ Between now and 2020, Statnett will be investing NOK 5 billion annually in new transmission projects. Political discussions have only been minimally involved in this process. It appears that the need for security of supply is more significant in dictating grid development decisions than any political platform or support.

"Statnett has to take necessary decisions on politically neutral basis as long as the politicians are not supplying them with guidelines to follow," emphasises Research Manager Ole Andreas Brekke of Uni Research's Stein Rokkan Centre for Social Studies. He and his colleague Hogne Lerøy Sataøen are finalising a comparative study of grid development regimes in Norway, Sweden and the UK.

There is little that ties together local energy reports, regional power system reports, and Statnett's grid development plan. Legitimacy issues arise because it is more difficult to communicate power system-oriented decisions than political decisions. In addition, many players do not get involved until after the Norwegian Water Resources and Energy Directorate (NVE) has taken a decision, which is when they can appeal to the Ministry of Petroleum and Energy. This adds time and cost to the development process.

The Hardanger case ■ This was evident in the 2010 conflict over the path selected for suspended power lines (Sima-to-Samnanger) along the Hardanger fjord in Western Norway. In a pilot study, project manager Audun Ruud and his colleagues Jens Jacob Kielland Haug and William Lafferty, all from SINTEF Energy Research, found that key community players had more to gain from protesting through informal channels such as the media than from participating in the formal processes.

"Some parties clearly felt it was to their advantage to protest after the decision was taken instead of taking part in the formal processes – even though they had the opportunity to be heard," says Ruud.

"We need to establish a new political decision-making system – a new consultative review regime – that can better integrate informal and formal aspects. The appeals bodies

CEDREN studies provide knowledge for improved planning tools and governance procedures facilitating public acceptance and consensual realization of grid projects. Photo: Statnett

are not completely well-suited to today's society; many of them focus just as much on media comments and the social media as on the established, formal processes."

Public acceptance of grid expansion In another study, Senior Research Scientist Øystein Aas of the Norwegian Institute for Nature Research (NINA) found that the Norwegian public in general is positively inclined towards grid expansion, but that the average inhabitant has little knowledge about the grid and the players involved.

"The study also examined people's viewpoints on alternative actions and to what extent various measures would make them more acceptable," says Aas. Not surprisingly, cables laid underground or along the fjord bed were measures deemed more acceptable.

"Interestingly, some well-founded power line corridors emerged as viable alternatives, particularly those routed near existing infrastructure such as roads, railways, and other power lines, and away from residential areas, schools, day care centres and valuable natural surroundings. Norwegians see the planning process for establishing new power lines as an essentially centralised process steered by the energy industry and the energy authorities, so that local communities have little say in the matter."

Key figures

Personnel In 2011 a total of 110 researchers were involved in CEDREN.

In addition, CEDREN had 16 PhD and 4 Post-docs positions in 2011. Eight of these are Norwegian, and eight are female. Two PhD and one Post doc students finalized their work in 2011. CEDREN also had 10 MSc-students in 2011. Seven of these are Norwegian, and four are female.

Funding and cost The total funding in 2011, excluding in-kind, was NOK 64 601 802. In addition, the consortium partners had an in-kind contribution of NOK 11 341 231.

Table 1. CEDREN funding pr. partner in 2011 [NOK]

Partner	Funding
Agder Energi AS	1 107 000
BKK AS	250 000
E-CO Vannkraft	700 000
Eidsiva Vannkraft	300 000
Energi Norge	650 000
Norsk Hydro Produksjon AS	400 000
Sira-Kvina kraftselskap	500 000
Statkraft AS	6 567 000
Statnett	500 000
TrønderEnergi Kraft	100 000
Direktoratet for naturforvaltning	750 000
NVE	430 000
Hafslund Nett AS	150 000
NTE Nett AS	100 000
Troms Kraft Nett AS	80 000
Others	280 000
Transfers from other years	3 492 672
RCN Grant FME	15 793 459
RCN Grant RENERGI	18 681 355
RCN Grant SusGrid	1 370 290
RCN Grant Infrastructure	12 400 026
Total	64 601 802

Table 2. CEDREN cost pr. project and pr. partner in 2011 [NOK]

Project	Cost
Management	3 625 741
Common Centre Activities	5 743 474
BirdWind	1 739 954
EnviDORR	4 980 917
EnviPEAK	12 557 467
HydroPEAK	9 364 856
GOVREP	5 164 151
OPTIPOL	4 241 481
HydroBalance Phase I	1 555 211
Environmental Management Concepts	324 484
SusGrid	2 795 557
Research Infrastructure	12 508 509
Total	64 601 802
Partner	**Cost**
SINTEF Energy Research*	24 946 173
NINA	19 341 378
NTNU	16 832 004
LFI at University of Oslo	582 849
NIVA	414 614
Uni Research	2 478 715
Others	6 068
Total	64 601 802

** Including international partners*

CEDREN and BioForsk scientists discussing water needs with a local Water User Association in Mendora village in India. CEDREN is engaged in different international activities ranging from seminars and training in developing countries to scientific collaboration world-wide.
Photo: Tor Haakon Bakken, SINTEF

Publications

Table 3. CEDREN publications and dissemination measures in 2011. A complete list of publications can be found at www.cedren.no.

Type of publication	Total
Articles published in scientific/scholary journals or series	10
Articles published in anthologies	2
Monographs published	2
Reports, memoranda	22
Master thesis	10
Articles, presentations at International conferences	37
Articles, presentations at National and international seminars and meetings	32
Media articles referring CEDREN or popular science articles	310

Renewable energy **respecting nature!**

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