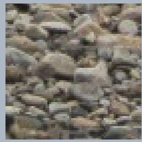

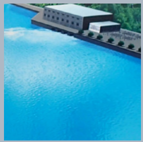

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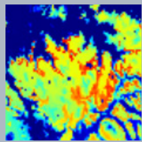

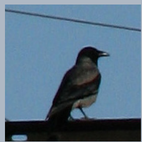

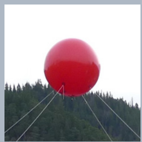

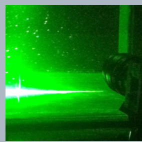

ANNUAL REPORT

2013

CEDREN Centre for Environmental Design of Renewable Energy

FME 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.

CEDREN Centre for Environmental Design of Renewable Energy

CENTRE FOR ENVIRONMENT-FRIENDLY ENERGY RESEARCH

Report of the **Board**

The year now behind us was our fifth year of operation. In 2013, CEDREN and the other research centres established under the FME scheme, faced an important and exciting cross-road, the mid-term evaluation required up by the Research Council of Norway (RCN).

In addition to assessments from ourself and all of our partners, an international expert panel was set up to assess CEDREN's activities and results so far, and to advise RCN as to whether or not to continue for three more years. On March 7, the Centre Management and some members of the Board had the pleasure of meeting the panel.

The mid-term evaluation came to the following positive conclusions:

- CEDREN is a well-functioning research organization that produces research results on renewable energy-related topics of scientific and technical as well as environmental and socioeconomic importance
- The Centre's outreach into the Norwegian community is considerable and has contributed to changes in societal attitudes towards hydropower
- The Centre has designed a setup of qualitative and quantitative success criteria that can be followed systematically and are demonstrably helpful in monitoring the progress of the Centre. The panel wishes to commend the Centre for this initiative, which could serve as a model for other similarly organised research centres. The way the Centre has utilised SWOT analysis as a tool when formulating the work plan for the last three years is also commendable

In June 2013 we were pleased to note that RCN also had faith in CEDREN, and gave us the green light tocontinue our activities.

However, some challenges remain with regards to funding, since several projects that have been with us since our launch have already come to an end, or have entered their final phase. CEDREN has put large efforts in summing up and communicating main findings and conclusions in these projects. In this situation the Board is pleased to note that several new applications for funding are planned. The major project "HydroBalance" was approved by RCN last summer, and will be performed by CEDREN (25 MNOK).

We also wish to emphasise the importance of application-oriented research moving ahead, and through our

The **CEDREN Board** has nine members and one observer from the Research Council. The industry partners elect four representatives among themselves for two years. Jan Alne (Statkraft), Jan Bråten (Statnett), Øyvind Stakkeland (Agder) and Geir Taugbøl (EnergiNorge) are representing the industry. The Directorate for Water and Energy has appointed Torodd Jensen to the Board. The Environment Agency has appointed Reidar Dahl to the Board. The research and university partners have appointed Petter Støa (SINTEF Energi), Signe Nybø (NINA) and Geir Walsø (NTNU) to the Board.

Researchers, students and user partners in dialogue about innovation and implementation of research results during the Annual Seminar. Photo: Claude Olsen

Committee for Innovation and Implementation (KIM) we are pleased to note that the Centre Management has a good structure for focusing and following this up.

The Board believes that the topics that were introduced when the FME scheme and CEDREN were set up in 2008 are at least as relevant today. Our tasks will continue to be important in the future, and at the interface between technology, nature and society, CEDREN is a unique and well-established arena that is capable of making a difference, through:

- delivering relevant and fact-based knowledge
- providing exciting and meaningful work for everyone who is involved in and around the centre

Finally, the Board wishes to express its gratitude to everyone involved for their first-class efforts during the past year; we look forward to continuing our excellent collaboration!

On behalf of the Board of CEDREN

Jan Alne
Chair

CEDREN in **2013**

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.

CEDREN passed the mid-term evaluation with many positive comments from user partners, and the assessment from the scientific committee on the research activities is very positive. It states that CEDREN clearly demonstrate its leadership at the national and international levels through the excellence of its research. CEDREN has become highly visible in Norway; media and politicians have consulted centre researchers many times. CEDREN has extensive international contacts and is on its way to an internationally recognised identity. CEDREN is well organised with the tasks of board, management and the different committees clearly defined. Most of the user partners are very satisfied with CEDREN, but there is a potential for further implementation of results in the industry and by the authorities.

Many of the activities and projects that started when CEDREN was initiated in 2009 have ended in 2013 or entered their final phase. This is reflected in the increased focus to disseminate and implement results from the research.

The committee for innovation and implementation (KIM) in CEDREN has a revised mandate and has made good progress in helping to disseminate and implement research results. A handbook for environmental design of regulated salmon rivers, promising methods for power line siting and a tool for analysis of variable flows in rivers downstream power plants are among the results brought forward by KIM.

CEDREN funded four post-docs and 16 PhD students in 2013. 16 master theses were completed in CEDREN in 2013.

In 2013, the new CEDREN project HydroBalance was funded by the EnergiX-program at the Research Council of Norway – looking into challenges and opportunities for large-scale balancing and energy storage for Norwegian hydropower. The project also involves active participation by European energy companies and research institutes which is crucial for a better understanding of the future potential and barriers.

CEDREN received support for "infrastructure for environmental design of renewable energy research" from the Research Council of Norway, giving us the opportunity to monitor seabird behaviour close to offshore wind power plants, track fish migration, study flow patterns in close details, study evaporation and to map hydropower reservoir bathymetry.

CEDREN has been quite visible internationally in 2013 by participating in many meetings, seminars and conferences.

CEDREN also started collaboration in China with the goal to exchange knowledge in sustainable hydropower development and better use of hydro reservoirs for large-scale balancing and energy storage. CEDREN also organized a successful seminar in Mumbai to enhance Indo-Norwegian research collaboration in renewable energy.

Torbjørn Forseth (left) and Atle Harby have edited the new book "Handbook for environmental design in regulated salmon rivers". The book is a result of the project EnviDORR, and it was presented to the authorities and utilities in September 2013. Photo: Atle Abelsen

CEDREN has initiated several large projects by first starting pilot studies looking into existing knowledge and scoping of needed research for new activities. New activities related to two-way solutions for fish migration, challenges and mitigation of gas supersaturation downstream hydropower plants, climate change impacts and mitigation, policy challenges related to re-licensing, the Water Framework Directive and RES-targets as well as methods for siting of wind power plants and power lines are all highlighted in CEDREN by new pilot studies.

Atle Harby
CEDREN Director

CEDREN **portfolio** 2013

The CEDREN research portfolio consists of ten main projects. The projects encompass hydro power, wind power, power transmission and governance – with research comprising technology, biology and social sciences.

Two of the projects started in 2007 and was included in the CEDREN portfolio in 2009 when the centre was established. BirdWind was concluded in 2012, and FutureHydro and HydroBalance was included in 2013 with funding from the Research Council of Norway and the energy industry.

		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.	2007-2012	23 mill NOK	Kjetil Bevanger
EnviDORR	Increased power and salmon production. Environmentally designed operation of regulated rivers.	2007-2014	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.	2009-2014	37 mill NOK	Tor Haakon Bakken
HydroPEAK	Future hydropower design. Studies on hydropower development for peaking and load balancing.	2009-2014	36,8 mill NOK	Ånund Killingtveit
GOVREP	How to combine environmental and energy policy concerns. Governance for renewable electricity production	2009-2013	15,6 mill NOK	Audun Ruud
OPTIPOL	Optimal design and routing of power lines. In ecological, technical and economic perspectives.	2009-2014	19,2 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	13,5 mill NOK	Håkon Sundt
FutureHydro	Sustainable hydropower development in China and Norway to meet future demands	2012-2015	5,6 mill NOK	Atle Harby
HydroBalance	Large-scale balancing and energy storage from Norwegian hydropower	2013-2017	24,9 mill NOK	Michael Belsnes

HydroBalance

After finishing a pilot study showing the technical potential for large-scale balancing and energy storage from Norwegian hydropower, CEDREN has started a larger and broader project in 2013 for four years to focus on:

- Roadmap for energy balancing from hydropower
- Future demand for storage and balancing services
- Relevant business models
- Environmental impacts
- Social acceptance and regulatory framework

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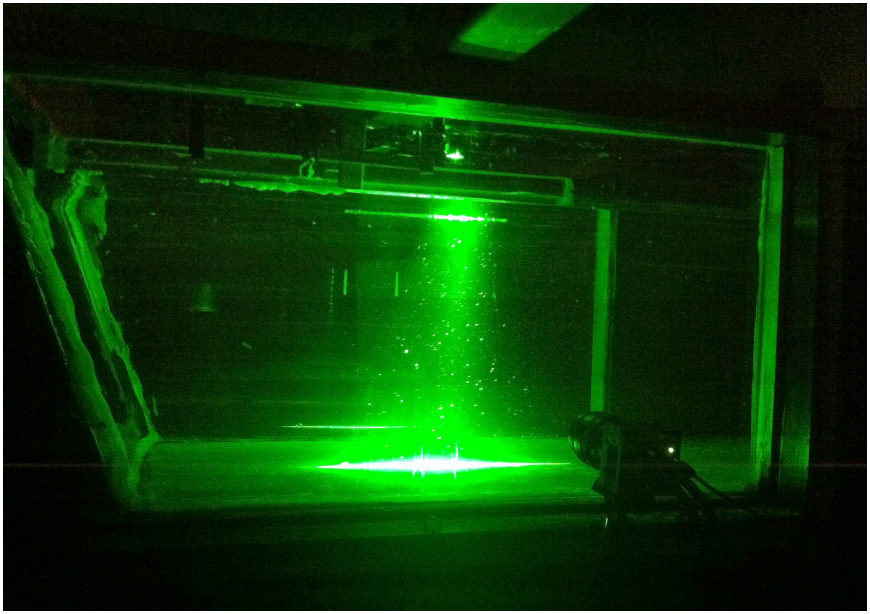
Photo: Atle Harby



High-quality laboratory and field equipment are essential for conducting top-level research. In 2013 CEDREN received funding from RCN for research infrastructure connected to several of the centre research areas. On the picture we see a Particle Image Velocity meter (PIV) used for highly accurate measurements of 3D velocity in the research flume at the hydraulic laboratory. Photo: Jochen Aberle

Reconstructing **historical** flow data for rivers

What was the flow in a river like before it was regulated for electricity generation? This can be difficult to estimate in the absence of measured data. However, CEDREN has developed a modelling tool that can simulate the flow in a river before it was regulated for hydropower production.

The model can be of help in the re-licensing process and the implementation of the Water Framework Directive. In such cases, a typical problem is that there are few or no historical data of a natural flow. This is required for good analysis of both hydrological and ecological impacts and mitigation measures.

When new environmental flows are discussed, the authorities and power companies can now take into account how the river would have been without regulation.

The simulation model has been successfully tested in the Lundesokna River south of Trondheim. This river lacked measurement data from its pre-regulation days.

Long-term research ■ We might think that it would be impossible to collect data about a river when no previous measurements exist. Today, this is done by using measurement data from nearby unregulated rivers through scaling methods based on catchment similarity. But finding unregulated data that matches the study site can be a challenge.

The ENKI hydrological framework model has developed methods for simulating an entire region with several catchments. The idea is that if we have measurement data for several catchments within a region and we calibrate the model for these, the parameters will also be correct for other rivers in the region that lack historical data. HydroPEAK doctoral candidate Teklu Hailegeorgis further developed this regional model and combined it with routines that can estimate the unregulated discharge of a river on an hourly basis.

Environmental design ■ The new tool will also be useful in connection with the diagnosis part of the CEDREN Handbook for Environmental Design in Regulated Salmon Rivers. Data from the simulations can show how river regulation has changed the flow pattern, and help understanding how to adapt modern environmental flow release.

The new method will provide more accurate discharge data, and will also be possible to estimate the uncertainty of the results.

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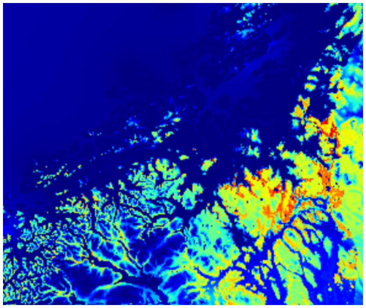

Even though old measurement data are not available, researchers can find out how the flow in the River Lundesokna (above) would have been if it had not been regulated. The ENKI model uses meteorological input data (left) to simulate runoff based on calibration data from large areas. Photo: Knut Alfredsen

Handbook for optimal **environmental** design

CEDREN's handbook for co-existence of hydropower and salmon looks as though it is destined to be a success. It offers users a solid knowledge base for evaluating and designing regulated salmon rivers for the benefit of the salmon, the local environment and electricity generation.

CEDREN is launching an English edition of its "Handbook for environmental design in regulated rivers". The decision to translate the book was based on strong interest from international partners and scientists all over the world when the Norwegian edition was presented in the media.

The main aim of the handbook is to enable optimal design of regulated salmon rivers with respect to both living conditions for salmon and the need for profitable electricity generation. Since salmon is an important ecological indicator, we can assume that a river is environmentally healthy if the salmon population is in good condition.

Norwegian hydropower companies are facing new requirements from the European Water Framework Directive, the Nature Diversity Act and revised concession licences. The handbook will be a very useful tool for identifying optimal solutions when new requirements have to be met.

Authoritative and easy to understand ■ The handbook has an authoritative and easily understood form, and includes a comprehensive list of references. The idea is that the threshold for using the book should be low among the utilities, the authorities and the consulting companies. The book is also intended to be an inspiration for decision-makers and the general public, demonstrating that is possible to identify solutions that benefit both the salmon and the hydropower production, as well as the environment in general.

The handbook is an example of practical application of CEDREN's core idea of environmental design. The methodology presented in the book can help to maintain, and in some cases even increase, electricity generation capacity, while supporting optimal conditions for salmon.

The group of researchers behind the book hope to to stimulate interdisciplinary cooperation and to provide a holistic perspective for improved solutions. These are topics that never become out of date. The handbook integrates ecology and hydrology into eco-hydrology. Together with hydropower competence, CEDREN believes that systematic methods from the handbook will facilitate more salmon and more power from regulated rivers.

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Part 1 - Diagnosis

Tools (D1-D7)

DATA COLLECTION AND TOOLS

- Mapping of river types, substrate and shelter
- Mapping of extent and spatial distribution of spawning area
- Relationship between wetted area and water flow
- Hydrological analyses
- Temperature data or modelling
- Collection of population data
- Description of hydropower system and regulation effects

CLASSIFICATION SYSTEMS

- The salmon population
- The hydropwer system

DIAGNOSIS

Habitat bottlenecks
- Shelter
- Spawning area

Hydrological bottlenecks
- Water flow
  - summer and winter flow
  - spawning water level ratio
  - smolt migration water flow
  - 0+ habitat
  - river habitat uniformity
  - habitat deterioration
- Water temperature
  - 0+ growth
  - smolt age

Del 2 – Design solutions

Measures (methods) (T1-T5)

DESIGN SOLUTIONS AND MEASURES

Habitat measures
- Shelter
  - cleaning of gravel banks
  - establishment of shelter
  - removal of weirs and other restoration measures
  - "river in river"
- Spawning habitat
  - cleaning of gravel banks
  - installation of spawning gravel

Water use
- Water temperature
  - flexible discharge systems
  - discharge volumes in key periods
  - active use of different water conduits
- Discharge
  - increased minimum, flow
  - redistribution
  - spawning water level discharge
  - situation-dependent discharges
  - expansions

ASSISTING TOOLS

- Building Block Method
- The Water Pool
- Flow duration curves
- Priority table
- Water negotiations
- Impact assessments water use
- Impact assessments habitat measures

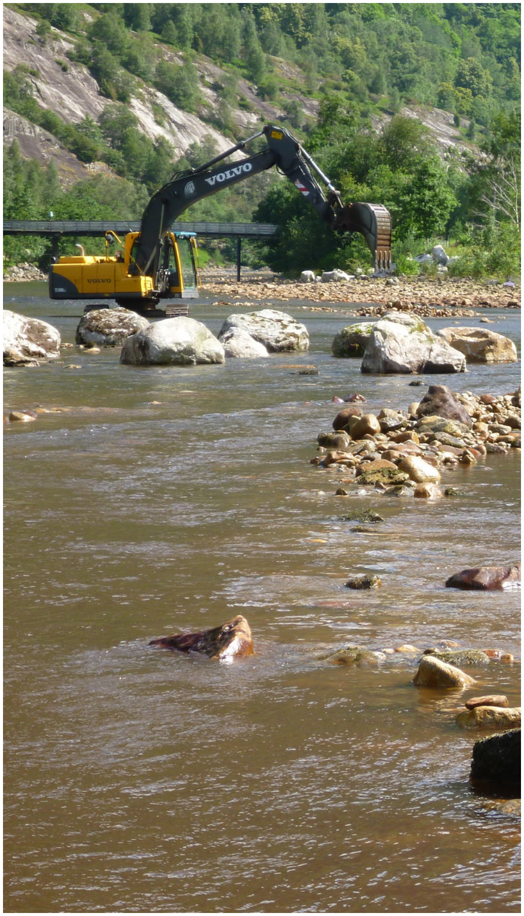

Photo: Ulrich Pulg

The handbook is organised into two main parts. The first part describes how to arrive at a diagnosis with a set of methods and tools. The second part describes how effective design solutions for water use and habitat measures can be developed and implemented.

How to **mitigate** impacts from hydropeaking?

Sudden changes in the hydropower production might lead to rapid changes in discharge and water levels affecting fish and other organisms negatively in the downstream river. EnviPEAK proposes a set of mitigating measures that will reduce the impacts.

Mitigation measures can be operational adjustments at the power plant, or physical changes in the rivers. A combination of both is often the best, but they all require good understanding of local conditions.

Hydro operations ■ The best mitigation to avoid negative impacts from hydropeaking may be to change the flow so slowly that organisms are able to adapt to the new flow situation. However, changes in hydro operation are limited by the technical possibilities to start and stop machines and power plants, and may therefore make mitigation more complicated. If hydropower production stops and water level decreases rapidly in the downstream river, fish and invertebrates might be trapped and strand in dewatered parts of the river. The risk of a fatal outcome depends on the time of the day and the season. Juvenile salmon and trout have the highest risk of stranding in day-light during the winter, as fish is less mobile then. Research has shown that water levels decreasing less rapid than 13 cm per hour reduces the risk of stranding.

Physical changes ■ Mitigation measures must be designed based on knowledge fish ability to handle hydropeaking in different seasons at different life-stages. Stable flow conditions should be provided in spawning periods at locations with proper substrate conditions for spawning. These locations must not be dewatered during the following winter. The spawning areas should also be close to areas providing good habitat for juveniles to facilitate easy access for the salmon and trout when they enter into the next life-stage.

The risk of stranding of fish in small isolated ponds might be reduced by smoothing out the bottom profile of the river. Water from tributaries can also be used to facilitate water to dewatered areas during low or zeropower production. Small weirs and other structures can be established for the purpose of keeping areas water-covered during low flow. Small retention basins introduced at the outlet of power plants, can reduce the magnitude and rate of change in water level. This kind of mitigation requires allocation of land or river corridor and may have other impacts on the environment, and the benefits must be weighed against the costs.

Modelling ■ Researchers in EnviPEAK have developed and applied the model IBSalmon to analyze the long-term trends in the salmon population effects due to hydropeaking. The model integrates all the life-stages of the salmon population and can hence be used to identify critical life-stages ('bottle-necks') in the population for a given set of scenarios for changes in the hydropower operation. The modelling exercise in Mandalselva in southern Norway showed that

Scientists investigating the dewatered zone in River Daleelva after changes in power plant operation. Photo: Tore Wiers

parr density (a juvenile life-stage) was reduced in parts of the river affected by hydropeaking-induced stranding, leading to an overall reduced parr abundance and smolt production. The effect on simulated salmon populations depended on when the hydropeaking was conducted: stranding during daylight in winter had greatest effect on parr abundance and smolt production; stranding during darkness in summer had least effect.

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Rivers and **waterways** under the microscope

CEDREN will enrich Norwegian research and industry with four new and highly competent doctoral degrees in the coming year. This new competence is very important for an industry that will be facing a wide range of challenges in the next decades.

The new doctorates focus particularly on erosion, sediment transport, ice conditions and ecological consequences in rivers, and stability and safety in waterways when the energy market requires more peak-power operation with more frequent flow and water level changes.

Norway has always kept a high level of competence related to hydropower development. Challenges in relation to important processes have now been under strong focus, strengthening and extending the knowledge. It will ensure that Norway will maintain a central position in international research in hydropower development. This is also reflected in the international network that the doctoral students have established.

Basic research ■ Stephan Spiller has used modelling and laboratory experiments to investigate the physical effects on river-beds of rapid changes in flow. Norwegian rivers tend to have extremely stable beds, with little sediment transport.

Spiller has found that rapid changes in water level and high flow rates may cause pebbles on the river bed to move vertically and "knock holes" in the armour layer of the bed. This produces a certain amount of sediment transport that can cause problems for hydropower turbines, bridge structures and other man-made structures in waterways, although it does not necessarily have negative consequences for the environment. If it happens during non-critical periods for spawning fish, it may even contribute to a richer habitat for life in the river.

Tunnels ■ Kari Bråtveit has studied how sand-traps in water tunnels function, and has also further developed methods for calculating roughness and friction in tunnels. These are important factors for analysing and modelling friction in a blasted hydropower tunnel correctly.

Her doctoral work involve modelling one of the sand-traps in Tonstad power station, which has experienced problems from large quantities of sand and stones that damage the turbine rotors. This is a consequence of more peak-power operation with frequent starts and stops and higher rates of water use than used to be the norm. This mode of operation carries down more of the loose material left in the tunnels at the end of construction.

Bråtveit used a well-known modelling tool for the first time for this purpose. The model has been verified by using advanced laser scanner installed in the sand-trap, a technique that has not been utilised previously. She has also used laser scanning to study roughness and friction in the tunnels, and used the modelling tools to analyses the results.

Dewatering Roser Casas-Mulet has been looking at how rapid changes in water level affect conditions in rivers. One of her findings is that salmon eggs tolerate dry conditions better than previously supposed. Eggs in dewatered areas are protected by much slower dewatering in the river sediments that cover the eggs.

On the other hand, eggs are extremely sensitive to frost, to which they can be severely exposed during dry periods in cold winter days.

Casas-Mulet has also developed a methodology for more accurate modelling of processes in dewatering zones. She has studied how these can be used in planning power plant operation. This is providing important knowledge that can be used for re-licensing and design of environmental flows.

Modelling ice conditions For his doctorate, Netra Prasad Timalsina has been studying how climate change is affecting ice conditions in rivers, and the potential consequences for hydropower production and ecological conditions in rivers.

Timalsina has demonstrated that it is possible to modify a current modelling tool to adapt it to Norwegian conditions by changing its source code and algorithms. This has enabled him to show that we can model several of the challenges that power producers either are already facing or will come to face in the near future.

Among other things, Timalsina has used the model to study climate change and how the models can be used to examine the effects of changes in ice conditions on the environment. His project has gathered data about ice in rivers during three seasons of field-work, and these data have been used to test the models. The data-set will also be useful for future model development and ice analysis.

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Tool for transparent decision-making

Analyses and decision-making processes regarding hydropower projects should be based on facts. But a good deal of judgement is often also involved when conclusions are drawn. Multi-criteria Analysis (MCA) is a tool that can help to distinguish between expert judgement and fact, and make conflicts of interest more visible.

CEDREN presents MCA as a useful tool for structuring discussions regarding impact assessments and other processes involved in hydropower projects.

Using a number of examples then we show how the tool is capable of structuring decisions in environmental impact analysis (EIA) in a number of ways. Advantages include obtaining a clearer definition of the decision problem, and a framework for sorting information to better understand potential and actual conflicts of interest. MCA offer good facilities for graphical presentations of problems and the significance of criteria.

Differentiating between opinion and facts ■ The most important advantage of using MCA in EIA is that it explicitly recognises the existence of subjective judgement. One challenge for regulators, and stakeholders has been that experts who conduct EIAs employ both facts and undocumented professional judgement in their evaluations. Professional judgement is always needed both with and without facts, but how can it be documented and weighted?

With MCA, we can distinguish between facts and judgement, and weight and evaluate the latter accordingly. This can make conflicts of interest and potential lines of conflict, for example between biodiversity and electricity generation, more visible. It will also make decision-making more transparent, open and clearly defined in turn can create a basis for discussion and conflict reduction.

CEDREN recommends that both the project developer and the Norwegian Water Resources and Energy Directorate (NVE) should use MCA to structure the documentation and information that are essential parts of the concession process.

The EcoManage project ■ The use of MCA in decision-making for hydropower projects is one of the topics in the EcoManage project. The main objective of EcoManage is to test, evaluate and adapt new concepts and indicators for the improved development and management of energy and water resources. The selected set of concepts and indicators to be studied are Energy Payback Ratio (EPR), water consumption in the hydropower sector and the off-set options for ecosystem services. MCA is a key tool in the study of whether biodiversity offsetting is ecologically and economically feasible in the hydropower sector in Norway.

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EcoManage is currently studying the use of multi-criteria analysis methods for improved decision-making in re-licensing and new hydropower projects. Photo: Ånund Killingtveit

CEDREN **abroad**

China is world leader in hydropower production and has further plans for large scale development. Environmental concerns are increasing, and there is a strong focus to preserve ecosystems and fish. CEDREN is currently cooperating with Chinese scientists on environmentally friendly hydropower development.

A delegation from CEDREN that organised a workshop on hydropower in Beijing and visited the Fengman power plant in 2013 found a strong desire among their Chinese hosts to mitigate environmental impacts in hydropower development projects. The Chinese have put large resources into collecting data and knowledge about fish and hydropower.

The Fengman hydropower plant on the Songhua River in the north-east province of Jilin, is an example of a major upgrading of an existing power plant. A new dam will be constructed just downstream the old dam, and the power generating capacity will increase from 1 200 to 1 480 MW. The power plant is used for peak production and large variations in flow and water level are dampened by a re-regulation dam some km further downstream. This is a good way of reducing impacts and will protect the downstream ecosystem.

Chinese authorities require the company that is developing Fengman to put 10 – 15 per cent of the total budget into environmental mitigation measures like fishways and fish stocking programs. CEDREN could contribute its expertise regarding the design of environmental measures and operation of the power plant.

Long-term collaboration ■ Cooperation between CEDREN and Chinese scientists started in 2010 and is now further enhanced with support from the Research Council of Norway. Additional funding to support exchange of knowledge about sustainable hydropower development and large-scale balancing of wind and solar energy with hydropower have been granted for three years. China is now world leader in both wind and hydropower production and can benefit from the combination of both. Norway has a similar potential to develop large-scale balancing power and energy storage for European renewable energy with reservoir hydropower and pumped storage. This is assessed in the HydroBalance project in CEDREN, bringing knowledge and results to exchange and discuss also with collaborating partners Tsinghua University, China Institute for Hydropower and Water Resources and North China University of Water Resources and Electric Power.

The 2013 workshop will be followed up by a separate Norwegian-Chinese session at the 10th International symposium on Ecohydraulics in Trondheim in June 2014 and a new workshop in China in the autumn. One part of the project will be to translate the "Handbook of Environmental Design in Regulated Salmon Rivers" into Chinese.

Collaboration in many parts of the world ■ CEDREN is also developing collaboration in other countries where sustainable hydropower and integration of other renewables are important topics. In 2013 CEDREN organised a Indo-Norwegian seminar on renewable energy in Mumbai to bring scientists from both countries together. On the other side of the Atlantic, CEDREN is collaborating with HydroNet,

Zhiguo Liu is showing and explaining how the new Fengman dam and power station on the Songhua River in North East China will look like after re-construction. Delegates from CEDREN and Chinese partners use the information for further discussions on collaboration. Photo: Peggy Zinke

a Canadian research network aimed at promoting sustainable hydropower and healthy aquatic ecosystems. CEDREN is following the situation in the European Union very close, especially related to the increasing development of wind and solar energy with the following demand for more storage of energy. Industry partners from Europe have already joined the HydroBalance project and CEDREN hope to engage in EU-funded research projects about large-scale balancing and energy storage for better integration of renewables. CEDREN is engaged in several international fora addressing topics like energy storage, carbon and water footprint of energy technologies, ecohydraulics, and bird protection among others.

To enhance collaboration between CEDREN and abroad scientists, CEDREN encourage scientists and students to go abroad for shorter and longer periods, and we also hope to attract more visiting scientists and students through special funding for guest scientist exchanges.

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The good, the best and the **ideal**

Norwegian energy policy has become the victim of widely differing social interests. There is now a great need for a thorough debate about how these interests should be prioritised and weighed against each other.

This need and these dilemmas were brought to light in the final report of the CEDREN project GOVREP, which was published last autumn. The report offers clear recommendations, related to strategic decisions at political level, more tactical decisions that concern the management of issues and the potential for individual stakeholders to make better decisions at operational level.

This should take place through a clear declaration of energy policy at the highest political level, via an energy white paper, which could identify essential boundaries and priorities.

Partially conflicting requirements ■ The EU Renewable Directive and the joint El-Certificate Market between Norway and Sweden were unanimously adopted in December 2011, virtually without debate. The Water Framework Directive and the Nature Diversity Act offer serious challenges to future concession processes, when new hydro- and wind-power projects will be dealt with.

One characteristic of political steering is its dependence on well-marked pathways – path dependence, and management processes are locked in place. Legislation becomes an excuse for not finding better, more integrated solutions. Politicians and the authorities need more knowledge that is relevant to decision-making. What would be a desirable outcome for Norway at large is not at all clear.

Norwegian electricity customers will share the cost of realising 26.4 TWh of renewable energy in Norway or Sweden by 2020, via the joint El-Certificate Market. Will half of this generating capacity really be realized in Norway? How will it be implemented with regard to the Water Framework Directive and the Nature Diversity Act?

How, for example, can we implement the Water Framework Directive, when its effects on societal concerns have still to be identified? What are the relative benefits to society of environmental protection and electricity generation?

Another unresolved topic is the outcome of the revision of concession conditions. These will also be related to the Water Framework Directive, but are based on legislation concerning hydropower production. Individual objects for revision need to be dealt with in a broader and better integrated context. Only then will itbe easier to identify good win-win solutions for power production and the environment.

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The GOVREP project, has identified a lack of clarity in political guidelines and management practice regarding new hydro- and wind-power development projects in Norway.
Photo: © Stortingsarkivet/photo: Teigens fotoatelier as.

Taking measures against **bird** fatalities

CEDREN has put a great deal of effort into increased understanding of why birds collide with power lines. Effective measures against these accidents could improve the viability of certain bird species and save consumers, grid and electricity companies heavy costs when birds short-circuit cables.

Every year, large numbers of birds die after colliding with power lines, or being electrocuted when they come into contact with two energized lines . This may affect how populations of certain species evolve, although that is very difficult to quantify. It is also a problem for electricity consumers and involves financial losses for electric power distribution companies when lines short-circuit.

CEDREN has made a desk study on the extent and causes of bird deaths connected to utility structures, and suggested various measures to reduce the problem.

Tailor-made ■ One important finding is that the death of birds as a result of electrocution or collision with power lines is extremely specific to the species, location and season. Preventive measures must therefore be tailored according to where and when such accidents happen and to the species that are involved in each individual case. There are large differences in terms of how well species can see under various weather and light conditions, how good they are at manoeuvring in the air, and their migration habits and patterns of movement in different types of terrain.

Another finding regarding bird electrocution is that a majority of these accidents involve a very small proportion of pylons. Implementing preventive measures in connection to these pylons would significantly reduce the number of bird deaths.

Measures ■ CEDREN has studied the usefulness and effects of a number of proposed measures to prevent bird electrocution An elevated prolongation of the cross arm have proved to be efficient to reduce electrocution of eagle owls in coastal areas.Other measures include various systems for scaring off birds or warning them by means of sounds, lights, or physically "enlargement" of the wires by attaching different types of spirals, balloons etc. to make them more visible to birds. These measures have proved to function to various degrees, and have different economic implications. Certain measures also have unfortunate consequences for the functionality, particularly in northern areas with occasionally high wind loads and risk of icing during winter.

One of the CEDREN reports discuss how lines and pylons can be made visible to birds, and at the same time be as less visible to humans as possible. This may turn out to be very challenging. One aspect is that bird vision differs from species to species, and definitely is very different from humans. Another is that we sometimes need to weigh the provision of visual warnings for birds against the desire for a minimal visibility for people.

Birds may easily be electrocuted when using the power-pole crossarm as a perching place as the distance between the phase conductors or between a phase conductor and a grounded device in many cases are very short. Photo: Kjetil Bevanger

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Conflicts may still **erupt**

Ever since the great "monster pylon" debate about the routing of the electricity grid in Hardanger, later grid development projects have been relatively uncontroversial. But have the grid developer and concerned stakeholders learned sufficiently to avoid similar conflicts in the future?

After all the controversy in 2010 on the Sima-Samnanger power line over Hardanger, Statnett started to plan the Ørskog-Sogndal line, without the same level of conflict. At the same time the Bergen-based grid company BKK Nett's Mongstad-Modalen line has gone smoothly. CEDREN scientists have studied and compared processes and conflicts in these projects, but are doubting whether experiences from the Hardanger controversy have created a more predictable and less contentious grid development procedures yet.

External quality assurance ■ The specific role played by individual grid companies has not really been discussed in the wake of the Hardanger conflict. External quality assurance of the grid proposal does not guarantee that local stakeholders will be consulted. But that is precisely what BKK Nett did in a highly systematic and open way in its Mongstad-Modalen project.

Statnett also adopted a similar approach to the new grid connection between Ørskog and Sogndal. Few people blame the grid company for the conflict that arose in Myklebostdalen (a part of the Ørskog-Sogndal line), which was rather the result of political interference by the Ministry of Petroleum and Energy.

The CEDREN study shows that anxiety about visual impact is a central driving force that can explain a significant part of the resistance to new grid projects, while fears regarding electromagnetic radiation are also involved to a certain extent.

Good choice of route ■ CEDREN's studies show that among other factors, a good choice of routing combined with removing outdated existing grid structures can help to reduce conflicts. When such solutions are included in the process, the confidence between the grid developer and stakeholders is growing.

We find successful examples of this in the Ørskog-Sogndal power line, where removing old grid has compensated for a new high-capacity grid connection that can offer local small electricity suppliers new development potential.

Most European countries face similar debates as the Norwegian "monster pylon". However, there are few examples in other countries of grid development projects being as politically explosive as the Hardanger controversy turned out to be.

Did the Hardanger project create massive public manifestations because it emerged too late into the public view? Are we about to enter an age of clearer and more coordinated political steering? CEDREN research suggests that a thorough and open justification of the need for grid development, combined with more thorough planning processes with more local involvement, would contribute to better and less contentious grid development projects.

The planned power line crossing of the picturesque Hardanger fjord caused public uproar against the project during the summer of 2010. Most European countries face public resistance to new grid development. CEDREN suggests better communication of the need for grid and an open planning process with more local involvement. Photo: Paul Sigve AmundsenSamfotoNTB scanpix

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Key **figures**

Personnel ■ More than 100 researchers where involved in CEDREN in 2013.

CEDREN were funding 16 PhDs and 4 Post-docs in 2013. Seven of these are Norwegian, and ten are female. CEDREN also had 16 MSc-students in 2013. Eleven of these are Norwegian, and seven are female.

Publications

CEDREN publications and dissemination measures in 2013. A complete list of publications can be found at www.cedren.no.

Type of publication	2013	Total
Articles published in scientific/scholary journals or series	30	56
Articles published in anthologies		3
Monographs published		3
Reports, memoranda	18	87
Masters thesis	16	55
Briefs		3
Articles, presentations at international conferences	20	127
Posters at international conferences	2	25
Articles, presentations at national and international seminars and meetings	54	173
Dissemination measures for the general public	4	29
Popular science articles and media articles referring to CEDREN	62	830

Funding and cost ■ The total funding in 2013, excluding in-kind, was NOK 32 844 078. In addition, the consortium partners had an in-kind contribution of NOK 7 368 589.

CEDREN funding in 2013.

Partner	Funding (NOK)
RCN Grant FME	8 015 695
RCN Grant RENERGI	1 955 000
RCN Grant SusGrid	2 041 117
RCN Grant EcoManage	2 680 353
RCN Grant FutureHydro	1 135 591
RCN Grant HydroBalance	542 053
Agder Energi AS	900 000
BKK AS	417 000
E-CO Vannkraft	700 000
Eidsiva Vannkraft	300 000
Energi Norge	700 000
Norsk Hydro Produksjon AS	400 000
Sira-Kvina kraftselskap	910 000
Statkraft AS	5 300 000
Statnett	1 200 000
TrønderEnergi Kraft	100 000
Miljødirektoratet	700 000
Norges vassdrags- og energidirektorat	280 000
Hafslund Nett AS	250 000
NTE Nett AS	100 000
Troms Kraft Nett AS	100 000
Others	378 559
Transfer from other years	3 738 710
Total	32 844 078

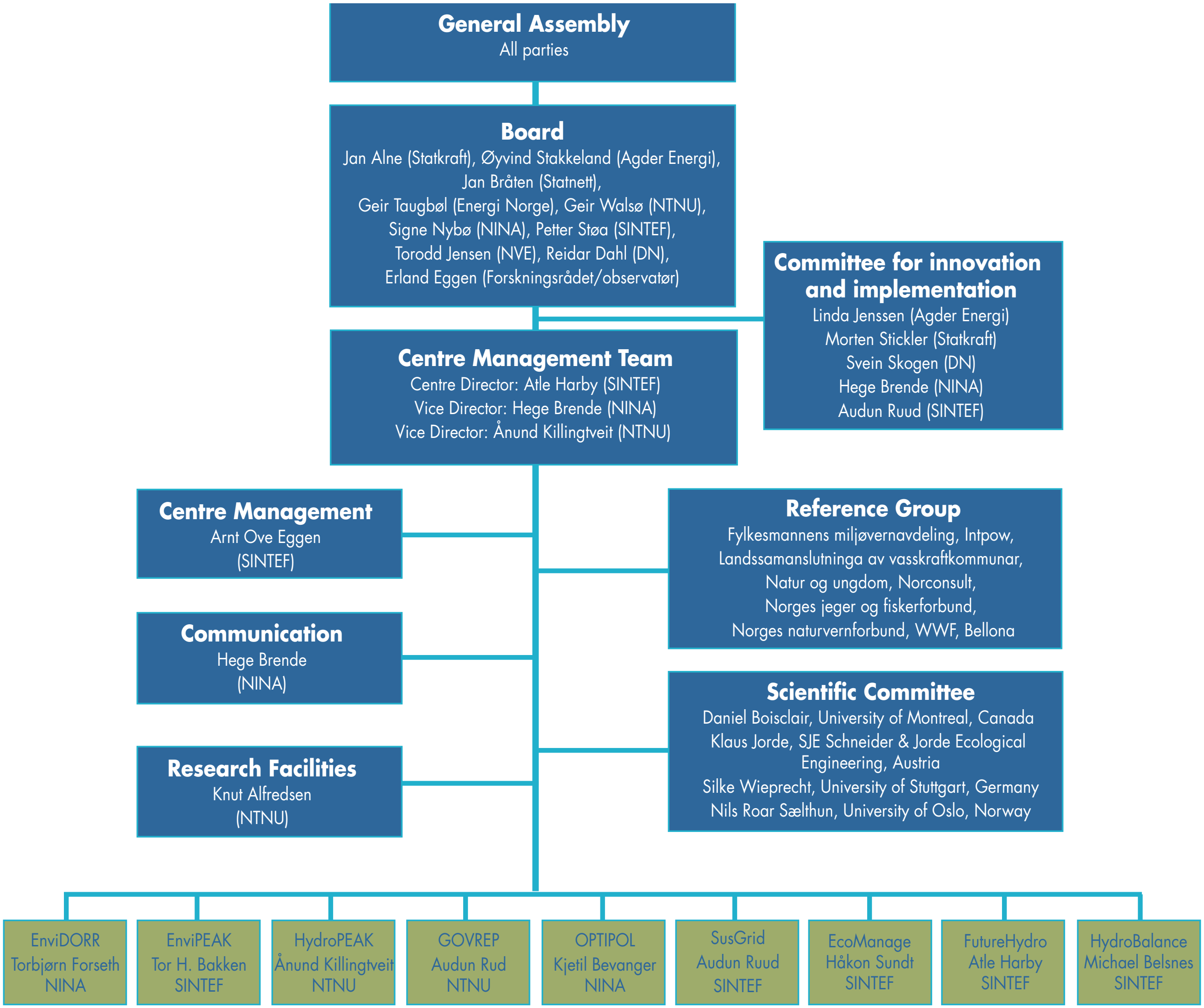
Cost per project and per partner in 2013.

Project	Cost (NOK)
Centre Management	3 546 937
Common Centre Activities	4 414 588
EnviDORR	1 861 522
EnviPEAK	4 503 467
HydroPEAK	5 258 192
GOVREP	393 080
OPTIPOL	3 327 248
SusGrid	3 661 420
EcoManage	3 772 485
FutureHydro	1 135 591
HydroBalance	969 551
TOTAL	32 844 078

Partner	Cost (NOK)
SINTEF Energy Research *	14 773 662
NINA	9 875 947
NTNU	7 449 436
LFI at UiO	140 486
NIVA	0
Uni Research	602 738
Others	1 810
TOTAL	32 844 078

* *Including international partners*

CEDREN organisational chart 2013



Renewable energy
respecting
nature!

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FME CENTRE FOR ENVIRONMENT-FRIENDLY ENERGY RESEARCH