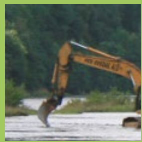

ANNUAL REPORT 2015

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

FME CENTRE FOR ENVIRONMENT-FRIENDLY ENERGY RESEARCH

Report of the **Board** – 2015

This has been our seventh year of operation, which means that we now are entering into the final stage of this eight-year regime.

The Board has been focusing on the idea that during this final year we need, even more than before, to emphasise communication of the valuable results that are gradually taking shape. Dig out "the diamonds from the gravel pitch", or present and disseminate "golden products" from CEDREN, has been a topic at all our four Board meetings in 2015.

The Board meeting in October was of special interest, due to the fact that it took place in combination with Hydro 2015 in Bordeaux - an international conference and exhibition with the headline "Advancing Policy and Practice in global hydropower development". More than 1000 delegates were gathered for three days, and several lectures were given by CEDREN-researchers and partners as well, leading to good discussions and exchange of knowledge, both at day-time and in the evenings.

We are seeing contours of the climate change challenges at both national and international levels, with for example more extreme weather events such as floods. This drives European energy policy towards de-carbonization and introduction of huge amounts of renewable energy. Hence, the Board is convinced that the need for environmental design of renewable energy will not become an outdated topic in the future – rather quite the opposite!

In this context, the Board is also pleased to notice that the view on hydropower seems to turn more balanced - probably not only due to CEDREN, but most likely this FME has contributed as well. Flexible hydropower with reservoirs has a potential to be a major element in the future energy system, in interaction with intermittent energy sources like wind and solar. In addition, reservoirs will also play an increasingly important role in the light of protecting the society from floods and droughts, linking water management to hydropower operations.

Even though CEDREN as a FME is entering the final year, we are happy to see that several projects within CEDREN will continue after 2016, and we foresee a wider use of results from earlier activities in CEDREN, especially related to environmental design of hydropower and wind power.

The Board is convinced that many of the "golden products" from CEDREN will contribute to the future challenges in the energy-climate-nature nexus, both for the industry and the authorities, which now can benefit from the results. In addition, the development of knowledge through for instance so far 13 PhDs and 85 Masters in CEDREN-topics has an important value in itself!

So, finally the Board wishes to express its gratitude to everyone involved for their first-class efforts during the past year, and we do look forward to continuing our excellent collaboration this last year!

On behalf of the Board of CEDREN

Jan Alne
Chair

Photo: Per Øyvind Grimsby

The **CEDREN Board** has nine members and one observer from the Research Council (Erland Eggen). The industry partners elect four representatives among themselves for two years. Jan Alne (Statkraft), Sigve Næss (BKK), Øyvind Stakkeland (Agder Energi) and Geir Taugbøl (EnergiNorge) represent the industry. The Norwegian Water Resources and Energy Directorate has appointed Torodd Jensen to the Board. The Norwegian Environment Agency has appointed Torfinn Sørensen to the Board. The research and university partners have appointed Petter Støa (SINTEF Energi), Signe Nybø (NINA) and Geir Walsø (NTNU) to the Board.

CEDREN in **2015**

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.

One important task is to finance PhDs and Master students, and to include them in the CEDREN research teams. In 2015, 3 PhDs and more than 11 master students obtained their degree. Hopefully, they will be recruited to work within the field of renewable energy bringing the most updated knowledge to their employers.

CEDREN has produced many results, methods, models and solutions that are available to other researchers as well as to industry, consultants, the authorities and other stakeholders. In 2015, we documented 17 new innovations and solutions that are ready for application also outside CEDREN, transforming knowledge into work. Several tools and models were also upgraded to be able to communicate with each other, allowing more holistic analysis.

Handbooks, text books and popular science documents from CEDREN are warmly welcomed by the industry and the authorities. Results and methods from several main topics within CEDREN are being published this way.

In 2015, CEDREN obtained funding to start two new projects; SafePass which deals with safe two-way migration of fish past power plants and other barriers, and SusWater focusing on both regulatory and natural science aspects related to the EU Water Framework Directive. These projects have a strong focus on case studies, and we are happy to see that end users are engaging in the activities.

Dialogue, discussions and information exchange between CEDREN researchers and its user partners and stakeholders are vital parts of our core business. Consequently, meetings and seminars between researchers and user partners in CEDREN are highly prioritised activities. In 2015, CEDREN organised five such meetings. In 2016, CEDREN wish to increase this activity, hoping also to be able to engage user partners and other stakeholder in bringing the knowledge to work.

CEDREN has now entered the final year with funding from the FME scheme, and will put a strong focus on dissemination and implementation of results. Even though the funding of the centre will end, the concept of environmental design of renewable energy will survive and the research partners will continue to work within environmental design together with the industry and the authorities.

Atle Harby
CEDREN Director

One of the "golden products" of CEDREN - environmental design of salmon rivers – was applied to Palmafossen in Vosso River to ensure increased power production and improved conditions for salmon. Photo: Hans-Petter Fjeldstad

CEDREN **portfolio** 2015

The CEDREN research portfolio consists of 13 main projects. The projects encompass hydro power, wind power, power transmission and governance – with research comprising technology, biology and social sciences.

The BirdWind and EnviDORR projects were started in 2007, and were included in the CEDREN portfolio in 2009 when CEDREN was established. SusGrid, EcoManage, FutureHydro, HydroBalance, SafePass and SusWater have been included after CEDREN was established. BirdWind was concluded in 2012, GOVREP was concluded in 2013, and OPTIPOL was concluded in 2014. EnviPEAK, SusGrid and FutureHydro were concluded in 2015.

		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.	2007-2016	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.	2009-2015	38,3 mill NOK	Tor Haakon Bakken
HydroPEAK	Future hydropower design. Studies on hydropower development for peaking and load balancing.	2009-2016	37 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	19,4 mill NOK	Kjetil Bevanger
Tools	Tools to improve efficiency of multi-model analysis and environment-friendly design of flexible hydropower.	2014-2016	5,0 mill NOK	Knut Alfredsen
SusGrid	Sustainable Grid Development. Improving planning tools, and governance procedures facilitating public acceptance and consensual realization of grid projects.	2011-2015	16,5 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.	2012-2016	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
SafePass	Safe and efficient two-way migration for salmonids and European eel past hydropower structures	2014-2019	24,5 mill NOK	Torbjørn Forseth
SusWater	Sustainable governance of river basins with Hydropower production	2014-2018	18 mill NOK	Audun Ruud

Photos: Tonstad power plant: Cedren laser scanner, White-tailed Eagle: Espen Lie Dahl, Fieldwork: Knut Alfredsen, Moose: NINA, Eagle owl: Frode Johansen, Smolt: Ulich Pulg, Excavator: Bjørn Barlaup, Water reservoir: Atle Harby, The Storting building: Stortingsarkivet/Teigens photoatelier AS

Airbag for hydropower

Air cushion surge chambers are airbags for hydropower plants. PhD candidate Kaspar Vereide is now designing one for the large hydropower project Upper Kontum in Vietnam.

When stopping a hydropower plant, a shock absorber is crucial to prevent a massive body of water from crashing into the plant with great force.

"Many Norwegian hydropower plants have over 10 kilometres long tunnels, with a cross section that surpasses most road tunnels. When suddenly stopping all this water, it is like if several semitrailers driving through the tunnel had to stop. This creates large compressive forces in the system," explains Kaspar Vereide.

Through the HydroPEAK project, he has done a PhD on air cushion surge chambers, a type of shock absorber that works like an airbag in the hydropower system.

Large mountain halls as airbags ■ To create an air cushion surge chamber, a mountain hall is constructed and filled with air. When the hydropower plant is switched off, the water flows into the mountain hall and compresses the air rather than crashing into the power plant.

«Norway's largest air cushion surge chamber is 120 000 m^3. In comparison, an auditorium at NTNU is between 10 000 and 20 000 m^3," says Vereide.

Design of an air cushion surge chamber in Vietnam ■ Vereide is now cooperating with Multiconsult to design an air cushion surge chamber for the 220 MW hydropower plant Upper Kontum, which is under construction on the river Se San in Vietnam.

Air cushion surge chambers are not very common, as they require certain geological conditions. Owing to the high pressure, the mountain can crack, and the air leak. On the other side, air cushion chambers do not depend on the surface topography, in contrary to conventional surge chambers, which are tunnels or shafts up to the surface.

"To make a conventional surge chamber at Upper Kontum, they would have had to build a 200 meter tall concrete tower on the surface, as there is not enough rock above the power plant," Vereide explains.

Advantages for pumped-storage facilities ■ Air cushion surge chambers also have advantages for pumped-storage plants, which are used to store energy in periods of power surplus by pumping water back into a reservoir.

There, the water flow must frequently change direction within a short amount of time. Because air cushion surge chambers can be placed close to the turbines, it is possible to make rapid changes in the power production without damaging the facility.

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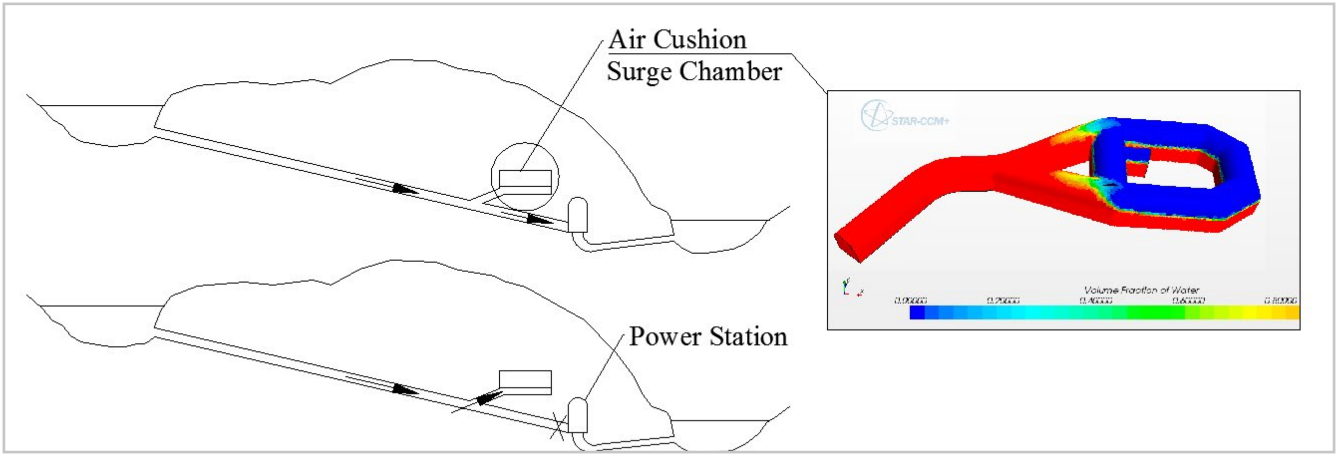

Top: In the NTNU hydraulic laboratory, Kaspar Vereide and his colleages have built a 1:65 scale model of an existing hydropower plant with an air cushioned surge chamber. Photo: Anne Olga Syverhuset

Lower: An air cushioned surge chamber works like an airbag. The coloured figure shows a 3D model of an air cushioned surge chamber. Air is shown in blue and water in red. Figure: Kaspar Vereide

Salmon **smolt behavior**

A challenge in many hydropower facilities is that downstream migrating fish can enter hydropower turbines where they may be injured or killed. In the SafePass project, we explore how fish migrate under different hydraulic conditions and use this knowledge to design solutions that prevent fish from entering turbines. To obtain this we need detailed information on how fish behave in front of power plant intakes.

Tracking the smolts ■ During the spring of 2015, we used acoustic tags and an array of receivers to follow the track of 91 salmon smolts as they passed the intake of Laudal Power Station in the Mandal River. Minute by minute we tracked the swimming directions and depths, providing a unique 3D dataset on the behavior of salmonid smolts. Moreover, by hydraulic modelling we have detailed information on hydraulic conditions such as water velocity and turbulence experienced by each fish.

Earlier experiments have shown that the diversion of flow between the power station and the bypass spill strongly effects the migration route. Now we can explain why some fish enter the intake tunnel whereas others select the safe bypass route.

Swimming routes ■ The figure to the right shows three salmon smolts that arrived at a similar position relative to the intake, but followed different routes. Fish 25 (green track) rapidly passed the intake area and was later recorded as it entered the bypass in the dam 500 m downstream. Fish 100 (brown track) swam more or less directly towards the intake, dived down (the tunnel intake is 3 m below the surface) and rapidly disappeared into the tunnel.

The last example fish (no. 48, blue track) was tracked for one hour. It swam towards the intake and dived down in front of the tunnel intake. After twenty minutes, the fish apparently changed its mind, left the intake area and safely passed over the downstream dam.

The SafePass team of scientists is now using the hydraulic models to understand the choices made by these three and the other 88 salmon smolts.

Proactive partner ■ Thanks the pro-active approach to environmental challenges adopted by the CEDREN partner Agder Energy, the Mandal River has for many years been used as a study site for the CEDREN projects EnviDORR, GOVREP, EcoManage and SafePass.

Tracking smolt in Orkla ■ In May 2016, the tracking set-up will be moved to the River Orkla in Central Norway, where also the effects of LED lights as a repulsion measure will also be tested.

The overall goal of both studies is to gain general knowledge on the migration process, as a foundation for developing effective measures in the numerous locations in Norway and elsewhere, where fish may enter into hydropower turbines.

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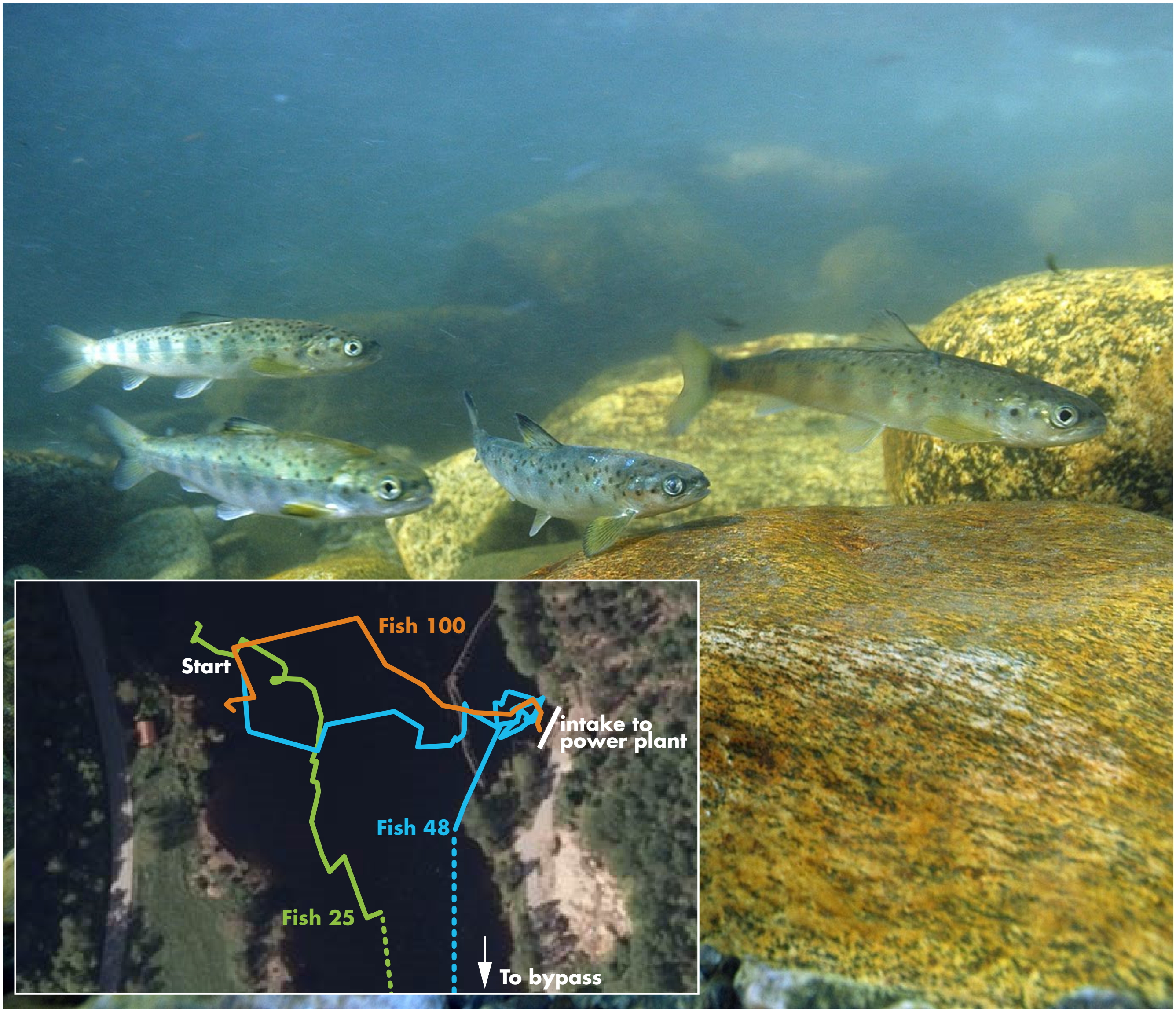

The figure shows the migration tracks of three salmon smolts from arriving to the study area (start) until they either migrated into the hydropower intake (and into the turbines) or left the intake area and migrated through the bypass in the downstream dam. Photo: Bjørn Barlaup

Flexible approach

Environmental design in regulated rivers can give more sustainable hydropower solutions. In order to achieve this, Norway needs a more flexible and holistic political approach.

Water Framework Directive ■ The EU Water Framework Directive (WFD) of 2000, implemented in Norway through the Water Regulation Act ("Vannforskriften"), introduces a new regulation technique: *Environmental quality standards*. The focus is more on how to improve the ecological condition of the water body and less oriented towards why the water body is in its current status. Rather than requiring a specific environmental flow, a minimum size of fish stock should be defined.

Quality standards ■ In order to use environmental quality standards, stakeholders need to gain better insight into the consequences of proposed measures in heavily regulated rivers, *so-called Heavily Modified Water Bodies*. Such water bodies may have less stringent targets, but they still need an environmental quality norm as a reference for how and when a desired ecological potential can be achieved. The current management plans agreed upon by the water regions, reflect such an approach.

Mitigation measures ■ The mitigation measures will be executed through the existing national hydropower legislation where a system and method for revisions of licenses is already in place. At the same time, mandatory plans for improving the ecological status must be developed by the regional water administration unit. These processes are not governed by the same ministries and require new ways of collaboration and implementation, creating regulatory challenges. The implementation of the WFD should be linked closely to revisions of hydropower licenses, but it is unclear how this will be combined in Norway. The possibility of using mitigation measures raises the need for working with scenarios, which is addressed in CEDREN.

Holistic approach ■ The expected costs of achieving required environmental status is a major concern. In this respect, it is interesting to follow the new hydropower projects in the Kvina River in Agder water region. There, environmental improvements are directly linked to increased water withdrawal from tributaries for both increased hydropower production and mitigating measures for the salmon stock. A water bank is kept for environmental use in existing reservoirs in the Kvina catchment and several measures such as fish ladders and habitat improvements are planned in the river. In addition, there will be more water also available for power production at the existing Tonstad power plant, creating a win-win solution for power and salmon. This holistic regulatory approach provides an important contribution to ensure a sustainable salmon population in the Kvina River. The SusWater project addresses these regulatory challenges and efforts of promoting environmental design and win-win solutions.

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A flexible approach from authorities, stakeholders and the power company in Kvina River is planned to give both environmental improvements and increased power production. Photo: Hans-Petter Fjeldstad

Improved **management tools**

The aim of EcoManage is to improve tools and indicators used to develop and manage water and energy resources. EcoManage aims to provide users with an improved methodological basis for determining the costs and benefits of ecosystem services in regulated rivers, also providing the best ways to compare and decide on future development of renewable energy.

We are introducing energy indicators and ecosystem services as tools. Energy indicators are tools for comparing energy efficiency of different renewable and non-renewable technologies. Ecosystem services means benefits that people obtain from a multitude of resources and processes supplied by natural ecosystems.

How well does hydropower work? ■ No energy production is without energy investment, neither in the construction phase nor in the operational phase. Different energy production technologies have different demands of energy input, so how do we choose the optimal technology or the best mix of energy production?

How does hydropower production compare to other energy production technologies? In EcoManage, two main energy indicators were selected: 1) Cumulative Energy Demand (CED), and 2) Energy Payback Ratio (EPR). Even though the system boundaries were different, hydropower came out as the technology with the best ratio between energy input and energy output, when compared to wind, biomass, coal and natural gas.

Looking at the bigger picture ■ Hydropower concessions in Norway are often approved individually for river sections. What cost-effect gains could be made for both power and salmon if hydropower licences were evaluated across several sites instead of one river section at a time? Using the concept of biodiversity offsetting, i.e. further improving one site while utilizing another site for increased power production, the scientists evaluated power production, salmon production and habitat restoration against each other to find the optimal mix of solutions through scenarios.

By analysing several important criteria for different stakeholders at the same time, a cost-effectiveness analysis showed that the gain in salmon production when releasing water was much higher in one of the sites. This means that it is more effective to carry out mitigation measures at this site, and maintain a high power production in the other site.

Numerical modelling in Mandal River showed that physical habitat restoration is more effective than increasing environmental flow when costs for power loss are included. Habitat improvements through weir removal also affect river aesthetics, as shown through photo-simulations. In addition, mesohabitat analysis before and after habitat adjustments showed that weir removal also provided a number of additional sites for recreational fishing.

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Photographs of current situations (upper left) and manipulated photo of simulated situation with weir removed (lower left). Manipulated photo of future situation with wier removed at 3 m^3/s (upper right) flow release (upper right) and 15 m^3/s (lower right) flow release. All photos from Mandal River. Photo: Berit Köhler/Hans-Petter Fjeldstad

Benefit for Europe

The HydroBalance project has looked into the profitability and feasibility of using Norwegian hydropower to balance wind and solar power in Europe. Production of solar and wind power depends heavily on weather conditions. Thus, the increasing use of these energy sources leads to a rising need to store energy between periods with too much and too little energy production to fit the demand.

In a study in HydroBalance, German researchers from Aachen University have studied the economic feasibility of using Norwegian hydropower to balance energy production and demand in Europe – the use of the so-called Norwegian "Green battery"

Benefit of using Norway as a green battery ■ Despite necessary investment costs, the study finds that using Norway as a green battery is profitable for Europe from a system point of view. As a basis for the study, a considerable increase in generation capacity for Norwegian hydropower, including pumped storage, and a corresponding increase in transmission capacity from Norway, were included.

"When adding the effects for producers and consumers in all countries, benefits exceed costs of building new capacity in both generation and transmission," concludes SINTEF researcher Ove Wolfgang, who leads a work package in HydroBalance.

The profitability for Norwegian hydropower producers ■ In the study, the German researchers calculated power prices for all European countries, including Norway. The Norwegian researchers use these results in their modelling, and through a case study in the upper part of the Otra River system, they looked at the profitability of investing in Norwegian pumped hydro storage towards 2050.

"Based on historical prices such an investment is not profitable, but in a future scenario with an integrated European power system it is profitable," Wolfgang summarizes.

International contribution ■ The power companies E.ON and EDF are international industrial partners in HydroBalance, contributing with in-kind, discussions and engagement. Together with researchers from Aachen University and ECN in Netherlands, they ensure a strong link and insight to continental Europe.

"We are cooperating with CEDREN to learn more about the technological and economic feasibility of this in 2050, to maybe have some business opportunities," says Michaela Harasta in E.ON.

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Last fall, German researchers from RWTH Aachen University visited Trondheim. In the HydroBalance project, they have performed a study to look at the economic feasibility of using Norwegian hydropower to balance energy production and demand in Europe. From left: Andreas Schaefer, Michaela Harasta (E.ON), Christoph Baumann and Andreas Maaz. Photo: Anne Olga Syverhuset

CEDREN **innovations**

CEDREN have developed several innovations and tools. Some are already applied in use. Below are three examples.

Siting of wind-power plants ■ ConSite is a tool for siting of powerlines and wind power plants developed in CEDREN. ConSite combines geographical and spatial data with stakeholder dialogue. ConSite is currently being developed for use in Lithuania through a project financed by EEA Grants. Lithuania expects to double its wind power production by 2020, and needs good methods to reduce the conflict between wind energy development and biodiversity protection. ConSite will help spatial planners in Lithuania to identify where conflicts between wind power and birds and bats are at the lowest possible level.

Environmental design applied ■ European hydropower companies are facing new environmental requirements through the EU Water Framework Directive, the Norwegian Biodiversity Law and the on-going revision of hydropower licenses.

The CEDREN Handbook on environmental design in regulated salmon rivers describes how to evaluate, develop and implement measures to improve living conditions for salmon populations in regulated rivers, while taking hydropower production into account.

"Contributions such as the CEDREN Handbook on environmental design are very important to our work" says Morten Stickler, Statkraft. The aim is to reach win-win solutions for both salmon and power production.

The Handbook was implemented by Statkraft in a regulated river in northern Sweden. Today, the Handbook is a key component for the planning of in-stream restoration measures, as well as the work of a multi-institutional steering group of the industry, local NGOs, municipality, and the county office.

"Common targets and actions have been established based on the approach that the Handbook offers", says Stickler. "The Handbook will also be an important contribution to our internal training regarding project development and refurbishment of existing hydropower plants".

Safe perching for eagle owls ■ Eagle owls use electricity pylons as hunting posts, but due to their large wingspan they are in danger of being electrocuted. CEDREN has developed an elevated prolongation of the power-pole cross-arm, providing safe perching. So far, 156 units have been produced by the Norwegian company EL-tjeneste AS and sold to grid owners, among them BKK, Nordmøre Energi and Agder Energi. According to special adviser at BKK, Kjell Skoglund, the experience so far is good. "We have observed eagle owls sitting on the device, and since they were installed there have been no reports of electrocuted birds."

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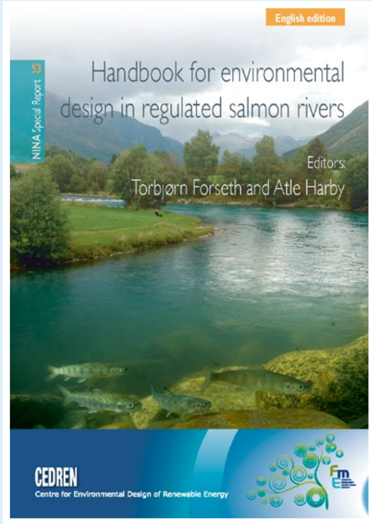
Examples of CEDREN innovations

CEDREN has developed an elevated prolongation of the power-pole cross-arm, providing safe perching for eagle owls. Photo: Jan Ove Gjershaug



The CEDREN Handbook on environmental design in regulated salmon rivers.

The decision analysis tool ConSite combines geographical and spatial data with stakeholder dialogue.
Photo: Frank Hanssen

CEDREN **abroad**

CEDREN aim to bring knowledge to the international society on one hand, and learn from international activities and collaboration on the other. In 2015, CEDREN have engaged in a broad range of international activities. Some examples are given below.

Interest in Norwegian hydropower ■ European academic societies, industry and authorities are showing increasing interest in Norwegian hydropower and its potential for large-scale balancing and energy storage. In 2015, CEDREN has participated in several meetings and conferences throughout Europe to present opportunities and challenges. CEDREN is also participating actively in relevant European fora such as the European Energy Research Alliance (EERA), and hope to be involved in several proposed EU projects.

International conferences ■ In 2015, CEDREN have participated in several international conferences. In this respect, the Hydro 2015 conference and exhibition should be especially mentioned. At the conference, CEDREN scientists and Board members presented research findings and projects. Furthermore, CEDREN participated in the Norwegian pavilion hosted by the networking organisation Intpow. The Board organised a board meeting during the conference.

Cooperation with China ■ In recent years, China has experienced a large increase in its renewable energy production capacity, and is now the world's largest producer of hydro, wind and solar power. In 2015, CEDREN scientists visited the University of Tsinghua and North China University for Water Resources and Electric Power to give lectures and discuss topics of common interest. CEDREN key topics like environmental design of hydropower and large-scale balancing with hydropower were also brought to China. The visit has resulted in several CEDREN reports and scientific papers. The CEDREN "Handbook for environmental design in regulated salmon rivers" has even been translated into Chinese!

Next generation ■ CEDREN is not only targeting end users from industry and authorities. In 2015, CEDREN gave lectures at a course for foreign students organised by NTNU, teaching students from all over Europe about various topics related to hydropower. The students are now back in their home countries with a better knowledge of hydropower.

EU collaboration ■ The European Union has programs to disseminate knowledge and discuss relevant topics with the candidate countries for membership in EU. CEDREN co-organised the seminar "Sustainable Development of Hydropower" in Istanbul with the European Commission Joint Research Centre, inviting participants from the Balkans and Turkey. Several other Norwegian organisations and companies also participated in the seminar. CEDREN aim to continue the collaboration with authorities, research institutes and universities in Europe to work together within the area of energy-nature-climate.

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CEDREN scientists gave lectures and participated in workshops and meetings in China, and are now publishing research results together with Chinese partners. Photo: Kari Dalen

Key **figures**

Personnel ■ More than 100 researchers were involved in CEDREN in 2015. CEDREN were funding 6 PhDs and 4 Post-docs in 2015. Three of these are Norwegian, and five are female. CEDREN also had 13 MSc-students in 2015. Eleven of these are Norwegian, and five are female.

Publications

CEDREN publications and dissemination measures in 2015. A complete list of publications can be found at www.cedren.no.

Type of publication	2015	Total
Articles published in scientific/scholary journals or series	23	111
Articles published in anthologies		3
Monographs published	3	13
Reports, memoranda	6	103
Masters thesis	13	86
Briefs	2	5
Articles, presentations at international conferences	15	204
Posters at international conferences		31
Articles, presentations at national and international seminars and meetings	44	256
Dissemination measures for the general public	18	50
Popular science articles and media articles referring to CEDREN	75	929

Funding and cost ■ The total funding in 2015, excluding in-kind, was NOK 37 573 759. In addition, the consortium partners had an in-kind contribution of NOK 6 539 633.

Partner	Funding (NOK)
RCN Grant FME	11 500 000
RCN Grant SusGrid	103 535
RCN Grant EcoManage	2 785 473
RCN Grant FutureHydro	500 000
RCN Grant HydroBalance	5 797 511
RCN Grant SafePass	2 691 000
RCN Grant SusWater	1 483 802
RCN Grant Infrastructure	1 917 540
Agder Energi AS	1 050 000
BKK AS	550 000
E-CO Energi AS	775 000
Eidsiva Vannkraft	500 000
Energi Norge	668 436
Hydro Energi AS	500 000
Sira-Kvina kraftselskap	1 050 000
Statkraft AS	5 050 000
Statnett	800 000
TrønderEnergi Kraft	250 000
Miljødirektoratet	350 000
NVE	280 000
NTE	100 000
Lyse Produksjon AS	550 000
SFE Produksjon AS	150 000
GLB	333 000
Akershus Energi	75 000
Others	1 463 377
Transfer from other years	-3 699 915
TOTAL	37 573 759

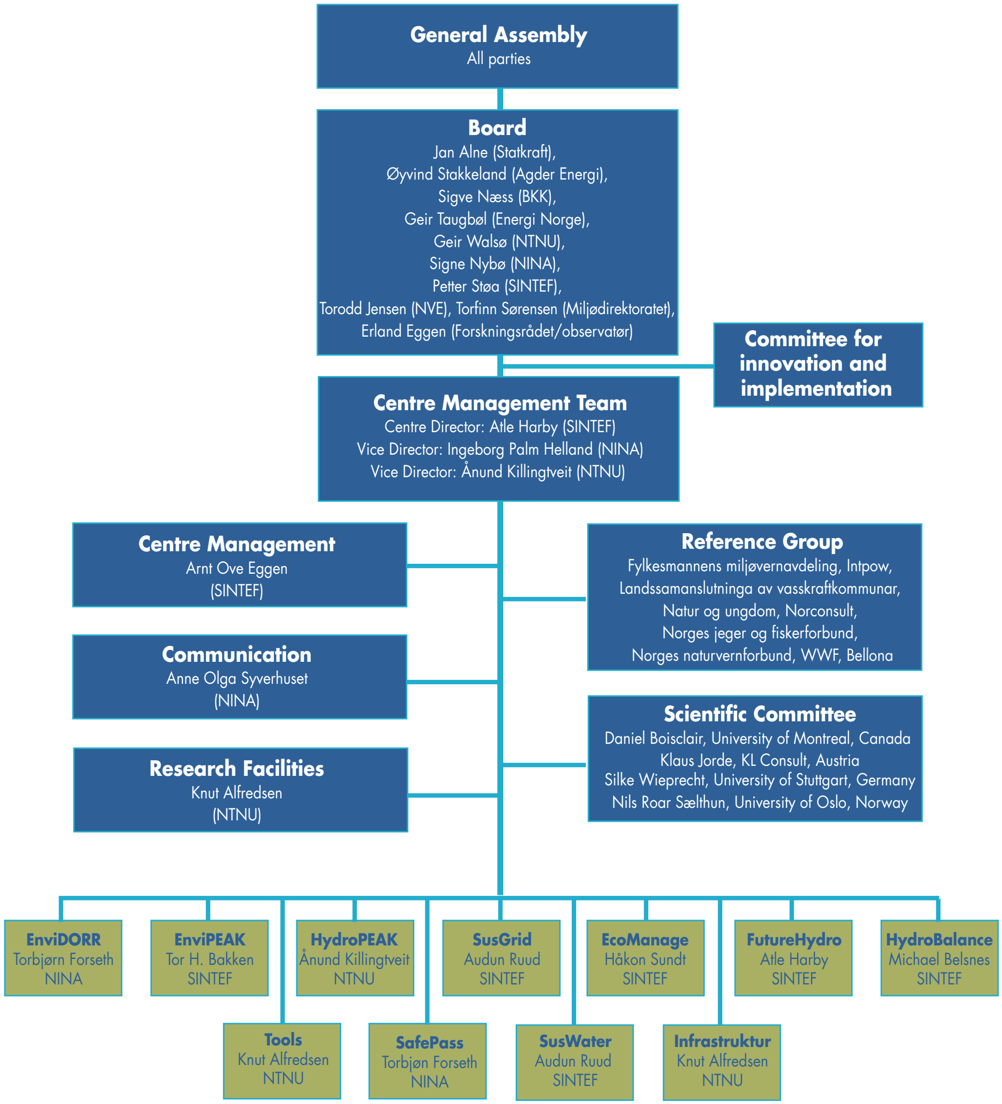
Cost per project and per partner in 2015.

Project	Cost (NOK)
Centre Management	2 845 168
Common Centre Activities	5 194 666
Pilot studies	1 664 127
EnviDORR	1 069 047
EnviPEAK	651 496
HydroPEAK	855 828
Tools	1 633 699
SusGrid	759 145
EcoManage	3 364 397
FutureHydro	958 549
HydroBalance	8 301 928
SafePass	5 750 163
SusWater	2 608 005
Infrastructure	1 917 540
TOTAL	37 573 759

Partner	Cost (NOK)
SINTEF Energy Research *	16 752 201
NINA	10 836 000
NTNU	7 325 021
LFI at UiO	318 880
NIVA	100 492
Uni Research	916 742
Others	1 324 423
TOTAL	37 573 759

* *Including international partners*

CEDREN organisational chart 2015



Renewable energy

respecting

nature!

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