CEDREN Centre for Environmental Design of Renewable Energy

CEDREN Annual Report 2009

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Ordningen med forskningssentre for miljøvennlig energi (FME) er et initiativ for å etablere tidsbegrensede forskningssentre som utfører fokusert og langsiktig forskningsinnsats på høyt internasjonalt nivå for å løse utfordringer på energi- og miljøområdet.

Sentrene ble valgt ut gjennom en detaljert vurderingsprosess administrert av Norges forskningsråd.
Vitenskapelig kvalitet, relevans og potensial for innovasjon og verdiskaping var de viktigste kritereine for å bli valgt.

CEDREN er ett av de 8 sentrene som ble opprettet i 2009.

CENTRE FOR
ENVIRONMENT-
FRIENDLY ENERGY
RESEARCH

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CEDREN Annual Report 2009

CEDREN Centre for Environmental Design of Renewable Energy

Trondheim, 26. March 2010

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PARTNERS

SINTEF Energi AS (SINTEF Energy Research)
Norsk institutt for naturforskning (NINA)
Norges teknisk-naturvitenskapelige universitet (NTNU)

Naturhistorisk museum v/Laboratoriet for ferskvannsøkologi og innlandsfisk (LFI) ved Universitetet i Oslo
Norsk institutt for vannforskning (NIVA)
UNI Research

Agder Energi Produksjon AS
BKK Produksjon AS
E-CO Vannkraft
Eidsiva Vannkraft AS
Energi Norge
Norsk Hydro Produksjon AS
International Centre for Hydropower
Sira-Kvina kraftselskap
Statkraft AS
Statnett SF
TrønderEnergi Kraft AS
Direktoratet for naturforvaltning (DN)
Norges vassdrags- og energidirektorat (NVE)

Summary

The main objective of **Centre for Environmental Design of Renewable Energy** (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.

CEDRENs vision is ***renewable energy respecting nature***.

CEDREN is managed by a Board, a Management Team and a Management Group. A Reference Group and a Scientific Committee will be established in 2010.

The main activities in 2009 were finalizing the Consortium Agreement and the contracts with the Research Council of Norway, and planning and initializing of the research projects.

9 PhD students and 2 Post-doc were engaged in 2009.

The total cost for CEDREN in 2009 was NOK 18 835 152,-. BirdWind and EnviDORR are excluded here since these projects made separate reports to the Research Council of Norway.

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1 CEDREN

1.1 Vision

CEDRENs vision is ***renewable energy respecting nature***.

1.2 Objectives

The main objective of CEDREN is to develop and communicate design solutions for renewable energy production that address environmental and societal challenges at local and global levels.

Sub-goals:

1. Technical redesigning of hydropower systems to allow peak loading and large scale balancing.
2. Developing improved tools for hydropower production planning addressing needs for resource management, power balancing and environmental design.
3. Developing methods to evaluate environmental effects of hydropeaking and identify and test mitigating measures.
4. Developing environmental design solutions to minimize local environmental impacts of power transmission and wind power systems.
5. Improving the governance of environmental issues related to renewable energy.
6. Establishing effective information and communication channels with key stakeholders, decision makers, media, and the public environmental design.

1.3 Description

While renewable energy sources like hydropower, on- and offshore wind, bio- and ocean energy are essential for reaching targets for reduction in greenhouse gas emissions, their local ecological and societal footprints may be large. Successful development and implementation of such energy systems thus depend on our ability to address the local challenges.

The vision of the Centre for Environmental Design of Renewable Energy, CEDREN, is to become an important instrument for addressing local environmental and societal challenges associated with renewable energy in Norway, starting with hydropower, onshore wind and transmission lines, and expanding into offshore wind and other renewable sources. The main challenge for hydropower is to develop technological and operational designs for balancing the increasing degree of uncontrolled renewable energy production while maintaining the ecological integrity of the associated ecosystems. For other renewables, the main challenges are to design systems that minimize environmental and societal impacts, and to understand the political, institutional and regulatory mechanisms involved.

The CEDREN consortium represents a unique collaboration of institutions with internationally recognised competence on hydropower design, hydrology and hydraulics, applied aquatic and terrestrial ecology and social sciences. This interdisciplinary group, working in close cooperation with a range of international scientists, industry and management will utilize modern experimental, field and numerical laboratories to meet the challenges of environmental design. Industry and management partners are strongly dedicated to the Centre objectives. PhDs and post-docs will form the core of the research activity and ensure education of relevant expertise. Due to the societal perspective of CEDREN, strong emphasis will be placed on the dissemination of results and interaction with society.

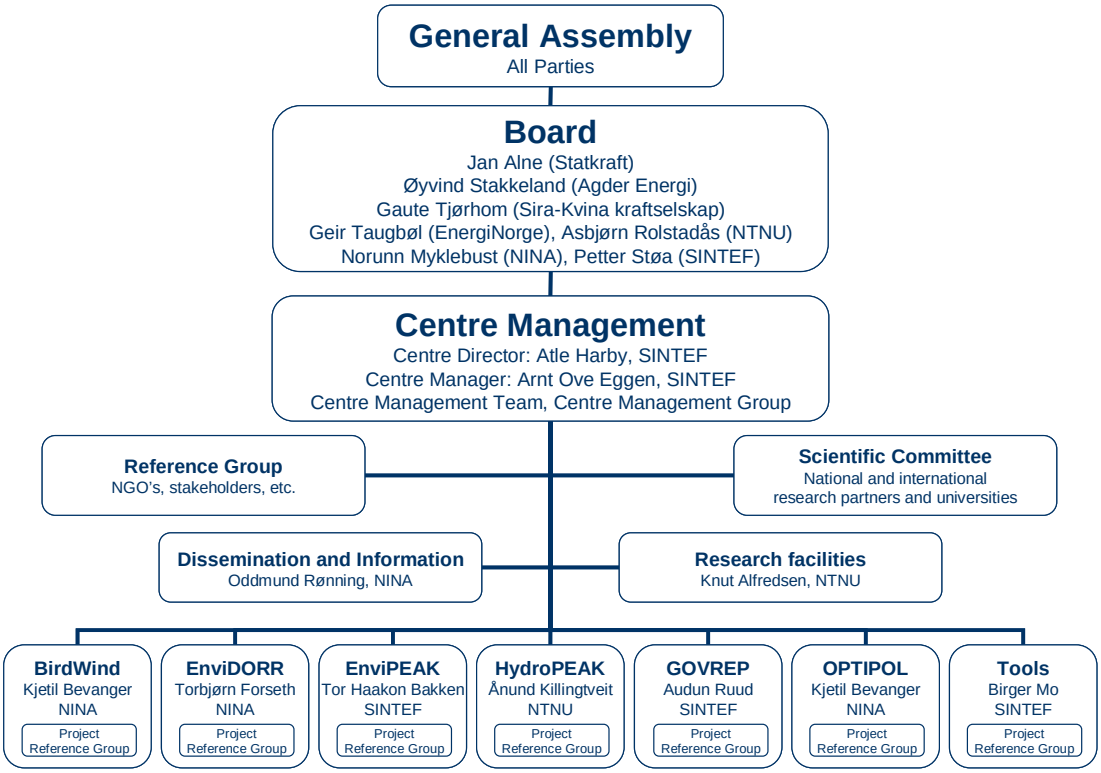
1.4 CEDREN partners

CEDREN consists of the following partners:

- SINTEF Energi AS (host institution)
- Norsk institutt for naturforskning (NINA)
- Norges Teknisk-Naturvitenskapelige Universitet (NTNU)
- Naturhistorisk museum v/Laboratoriet for ferskvannsøkologi og innlandsfisk ved Universitetet i Oslo (LFI)
- Norsk institutt for vannforskning (NIVA)
- UNI Research
- Agder Energi Produksjon AS
- Bergenshalvøens Kommunale Kraftselskap AS
- E-CO Vannkraft
- Eidsiva Vannkraft
- Energi Norge AS
- Norsk Hydro Produksjon AS
- International Centre for Hydropower (ICH)
- Sira-Kvina kraftselskap
- Statkraft AS
- Statnett
- TrønderEnergi Kraft AS
- Direktoratet for naturforvaltning (DN)
- Norges vassdrags- og energidirektorat (NVE)

1.5 Organisation

CEDREN is organised as shown in the following figure.



Industry parties are involved through representation in General Assembly and Board, and through involvement of the Centre Projects and Project Reference Groups.

CEDREN is managed by the Centre Director and the Centre Manager in close cooperation with the Centre Management Team (CMT) and the Centre Management Group (CMG).

The Centre Director is the leader of the CMT, which also consists of one representative from each of the main research partners NTNU and NINA.

The Centre Director is also the leader of the CMG, which consists of the CMT, the Centre Manager, Centre Project leaders, the leader of Dissemination and Information, and the leader of Research facilities. The CMG shall meet on a regular basis, preferably at least once per month.

Management staff will be appointed for follow up on administrative, financial and legal issues supporting the Centre Director in the day-to-day operation, hereunder also administration of the information sharing system (eRoom) where minutes of meetings, progress reports, deliverables and presentations will be shared between the parties.

SINTEF, as the host institution, has appointed Atle Harby as Centre Director and Arnt Ove Eggen as Centre Manager. NINA has appointed Kjetil Bevanger, and NTNU has appointed Ånund Killingtveit, to CMT.

CEDREN consists of the following centre projects:

- BirdWind – Pre- and post-construction studies of conflicts between birds and wind turbines in coastal Norway
  Centre Project leader: Kjetil Bevanger, NINA

- EnviDORR – Increased power and salmon production with Environmentally Designed Operation of Regulated Rivers
  Centre Project leader: Torbjørn Forseth, NINA

- EnviPEAK – Environmental impacts of hydropeaking
  Centre Project leader: Tor Haakon Bakken, SINTEF Energy Research

- HydroPEAK – Hydro power development for peaking and load balancing
  Centre Project leader: Ånund Killingtveit, NTNU

- GOVREP – GOVernance for Renewable Electricity Production
  Centre Project leader: Audun Ruud, SINTEF Energy Research

- OPTIPOL – Optimal design and routing of power lines; ecological, technical and economic perspectives
  Centre Project leader: Kjetil Bevanger, NINA

- Tools – Tools for hydropower production
  Centre Project leader: Birger Mo, SINTEF Energy Research

In addition, CEDREN consists of the following support functions:
- Dissemination and Information, headed by Oddmund Rønning, NINA
- Research Facilities, headed by Knut Alfredsen, NTNU

The Reference Group will consist of participants from the authorities, national and regional management and non-governmental organisations (NGOs). The Reference Group will be established in 2010, and give advise to the Board and Centre Management Group.

The Scientific Committee will give advice and guidance to the centre. It will, in collaboration with the Centre Director and Centre Project Managers, be responsible for developing a top quality Work Plan as well as PhD and post-doc programs. This includes an active recruitment strategy, invitation of international capacities for giving lectures, arrangements of scientific colloquia and seminars, and exposing scholars to industry and leading international research groups. The Scientific Committee will be established in 2010.

The organisational structure of CEDREN is focusing on collaboration through the projects. Scientists from the national and international research partners will work together in projects and meet the user partners.

2 RESEARCH PLAN / STRATEGY

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 will find a common site for development of future environmental friendly energy. The Centre will provide coordinated and increased effort to ensure maximum exploitation of excellent laboratory and field test sites for all activities. The Centre will also provide an extensive and coordinated dissemination of results and transfer of knowledge to the scientific community, the private sector (consultants and the energy industry), decision makers, management and the public.

The research methods in CEDREN will vary between the different tasks. Many scientific and technological challenges will be addressed by the use of laboratory and field studies in combination with numerical models. Together with training perspectives, this is the main reason why CEDREN includes operation and investment in research facilities.

CEDRENs main scientific activities are carried out in the projects. Each of the projects has separate research plans. For each year, the overall research plan is the basis for the Annual Work Plan.

3 SCIENTIFIC WORK AND RESULTS

3.1 BirdWind

Pre- and post-construction studies of conflicts between birds and wind turbines in coastal Norway

From 2007 inclusive, NINA has received economic support for research on wind power and birds from the Research Council of Norway through the RENERGI programme.

BirdWind is approaching its finalisation; with 2010 as the last ordinary year where data-collecting activities take place. In 2009 the project was significantly strengthened through a new PhD-position funded by Statkraft and NINA. The position is held for four years, and the overall aim of the work conducted by the PhD-student is to model the future white-tailed eagle (WTE) population development based on reproduction and mortality data.

Weekly searches with dogs for birds killed within the wind farm have been carried out throughout the year; in general searches are conducted every 7 days (plus or minus one day). 25 ‘primary turbines’ are selected and searched together with one of two dogs. A full search of all wind turbines is performed at larger intervals. In 2009 31 specimens of at least 8 species were recorded. The most frequent victims are willow ptarmigan and WTE with 10 and 7 carcasses, respectively. Of waders 3 common snipes were recorded. Five carcasses were recorded of hooded crow, and single carcasses of parrot crossbill, northern wheatear, teal and mallard. Some records from earlier years have been revised as collision victims or not.

Also in 2009 censuses for willow ptarmigan have been carried out in spring and autumn on Smøla and Hitra. The preliminary results do not indicate any obvious differences between the two areas, but autumn density in the wind farm area seems to be more stable compared to the control area. Interestingly the higher density within the wind farm area in autumn is evened out in spring each year, so also in spring 2009. To obtain data on habitat selection, movements, collision risks, survival of eggs, chicks and adults and general population dynamic parameters, willow ptarmigan specimen have been radio-tagged in 2008-2009.

The activities regarding breeding waders and small birds (mainly passerines) have this year focused on the EIA-activities on Hitra in connection to the planned extension of the existing wind farm on Hitra I; the Hitra II Wind Farm. Since 2003, 50 nestlings of white-tailed eagle have been equipped with satellite transmitters. In 2009, eight WTE nestlings were tagged, six with solar-powered and two with battery-powered transmitters. One was tagged within the wind farm, the others in close vicinity of it. The solar-powered transmitters used in 2009 were programmed to give one position per hour during summer in order to have finer resolution of movements for risk-modelling purposes. During winter less frequent downloading is scheduled, due to low light and poor battery-charging. One of the tagged nestlings was found killed by a wind turbine October 7.

We have continued to collect feathers from active nests and chicks also in 2009, as well as from eagles killed in collisions with wind turbines. DNA-analyses from bones of six eagles killed by electrocution on power-line pylons on Smøla will also be included. For increased efficiency in the laboratory, and to streamline the production of DNA-data, the use of an extraction robot has been implemented.

All WTE nest sites on Smøla were surveyed during the summer. Territorial activity, identified by either moulted adult feathers, chicks in the nest or fresh nest material, was confirmed in 61 different territories on the main island and in the surrounding archipelago. In these territories 27 chicks from 21 different clutches were recorded. This is the second highest number of chicks recorded ever on Smøla, giving a reproductive output of 0.44 chicks/confirmed occupied territory. In order to investigate behavioural differences for the WTE related to the distance from the turbines, data on flight activity (moving flight, social behaviour and soaring) and flight height (below, in and above the rotor zone) were collected at 12 vantage points, 6 from inside the wind farm area and 6 from control areas close to the wind farm. The results indicate that the WTE on Smøla does not have any behavioural responses to the wind farm constructions. It may, however, contribute to explain why the WTE is vulnerable to collisions with the turbines and the number of killed individuals recorded within the wind farm area. The results may also contribute to explain the high percentage of adults found killed in the wind farm area. The WTE has a peak activity early in the breeding period, which can be fatal to both adult individuals, and thus also to the nestlings. In 2009, all 30 dead WTEs recorded in connection to the wind farms on Smøla and Hitra have been examined. The eagle carcasses varied considerably with respect to what a post-mortem examination could reveal, and the condition of most carcasses did not allow for a thorough classic autopsy. All eagles were x-rayed and their damages were described. Three willow ptarmigan and one merlin recorded on Smøla were also autopsied. The precise findings and assessment will be presented later.

Seven camera systems were developed and deployed during spring 2008, and have been collecting data throughout the year. For the time being several terabytes is waiting to be analysed. The reason for this is that the system has a malfunction, being triggered by other movements than those of birds. It is not yet clarified with Statkraft how to proceed with the data analyses. The main focus regarding the avian radar has been the development of GIS-tools to learn more about the radar range and scanning accuracy, development of database routines to optimize radar data (including false alarms filtering and categorization of bird tracks using data-mining techniques). Experimental tests of the radar performance with respect to accuracy in detecting and following birds was done using model aircrafts and ground-truthing (identify bird species spotted by the radar by field observations). Methodological challenges of the radar system are to which extent the tracking-algorithm is able to record bird flights, the verification of recorded radar tracks to species and the characterisation of species-specific track-characteristics to enable extrapolation to the entire database. We have developed a web application, “WebTracks”, which allows radar tracks to be visualized together with ground-truthed data. This gives an instant view of where the radar might have low visibility. It also visualizes where the radar looses track of the object, and splits tracks into multiple segments, where they should have been contiguous. By selecting and displaying ground-truthed data, or model-aircraft tracks, together with tracks from the radar database in the same time interval, an instantaneous overview of the radar-tracking capabilities can be obtained. It is

possible to overlay both topographical maps, and clutter maps in the map window of the application. Together with colour coding of the objects height, the clutter map indicates where the object should be visible for the radar.

Based on laser elevation data from the laser scanning of Smøla in 2008 a high resolution terrain model was established in March 2009. The LIDAR data was delivered in LAS-format. The LIDAR DEM-model is an important input in the modelling of theoretical land-clutter areas and areas with wind turbine interference. These clutter and interference areas reduce the radar detection performance and have to be flagged as clutter in the database. The land-surface clutter model is nearly completed, but has to be further improved and tested before it is applied into the database as a mask to flag clutter pixels. This is an important step in order to be able to interpret the database.

3.2 EnviDORR

Increased power and salmon production with Environmentally Designed Operation of Regulated Rivers

We explore important gaps in our knowledge on different parts of the life cycle of Atlantic salmon relevant for designing environmental conditions that ensure long term viability and fish production in regulated rivers. By doing so we aim at providing design solutions that optimizes both salmon and hydropower production.

During spawning the salmon female assess different environmental factors before depositing her eggs. Based on extensive field data we can now describe and successfully construct (tested in five rivers) suitable habitat for spawning that can compensate for loss of spawning habitat in regulated rivers. We have also shown that small changes in operation of hydropower facilities can largely eliminate egg mortality due to dewatering or freezing. In the spring the eggs hatch and the fry emerge from the gravel to start feeding. In contrast to previous assumptions we showed in experiments in 2007 and 2008 that this stage is not very sensitive to low water temperatures. In 2009 we found that fry that emerges at low temperature are smaller but have more stored energy than fry that emerge at higher temperatures. Such information is vital as criteria for environmental hydropower operations during spring.

During the next two to five years the salmon parr must find shelter and food to grow and survive until they migrate to sea. The faster they grow, the more fish survive. We aim at understanding the environmental factors that ensure fast growth to replicate such conditions in regulated rivers. Studies in small experimental streams revealed that availability of shelter and local aggregation in high shelter areas was more important for fish growth than stream discharge. Based on detailed studies in natural rivers in 2009 we showed that the female choice of spawning sites strongly influences offspring local densities the next summer, and that fish density was the major determinant of growth. This underpins the importance of female spawning site selection and the need to ensure widely distributed spawning locations in regulated rivers.

In regulated rivers out-migrating smolts may enter hydropower turbines and be killed. If half of the smolts are killed, the number of returning adults is halved. To avoid turbine shut-down during the smolt migration period, we are developing strategies to guide smolts away from turbine intakes. In the river Mandalselva we have increased bypass migration from 10 % in 2003 to 64 % in 2008 by applying flow manipulation and strobe-lights that scares the fish. Spill of water during night are more effective than during daytime. We further explore links between the river environment and fish performance at sea by using existing data on smolt size and scale samples.

On their return to their natal river, adult migration may be hindered by hydropower dams. During 2009 Norway’s first experimental fish ladder facility was constructed, and during 2010 a number of experiments related to design of fishway entrance will be performed.

By accumulating new knowledge on bottleneck factors for fish production we work together with the industry and stakeholders to find good solutions for salmon and hydropower. In the River Surna environmental traffic lights are implemented as indicators for operational decisions in the power station management. The new knowledge has been used in restorations measures in other rivers. From 2009, the project was expanded to include effects of climate change on both salomid and power production. Based on five climate scenario we model discharge and temperature data to be entered into an individual, spatially explicit population model to provide ecological scenario in selected demo rivers. The first version of the salmon model is currently operational.

3.3 EnviPEAK

Environmental impacts of hydropeaking

The objectives of EnviPEAK are to develop knowledge and generic tools in order to analyze, predict and mitigate environmental impacts from hydro-peaking of hydro power plants. The project will carry out research on changes in both physical processes such as dewatering/wetting, hydromorphology, water temperature and ice formation and biological impacts on salmonid fish, invertebrates, mussels, mammals and birds. The research will make use of natural and semi-natural streams, experimental streams, laboratory facilities and numerical models in order to develop the knowledge to reach the overall objectives.

2009 was to a large extent a year dedicated for planning and initialization of the research activities. The project was kick-started in late March with meeting with end-users (authorities and hydro-power companies) and national and international experts present, giving clear feedback for the need of the project results and firm advices for the directions of the project.

Based on a follow-up workshop with a limited number of representatives from the hydro-power companies and a few selected researchers, a number of research sites and demonstrations sites were selected. These sites were selected based on the criteria that they should cover the range of problems to be addressed (relevance), build on preceding data collection and research, preferably be co-located with test sites applied by other CEDREN projects, and be in the vicinity of the researchers to carry out the field activity. Based on these criteria, the following network of sites was set up: Nea-Nidelva (pre-selected), Lundesokna, Surna, Daleelva, Mandalselva, Aurland, Barduelva, Orkla and Stjørdalselva, in addition to studies in the large recipients Holandsfjorden and Sirdalsvannet with connected storage reservoirs. As an outcome of the selection of research and demonstration sites, GIS-databases have been established, initially based on existing data/information and prepared to handle new data collected in the project.

Nidelva and Lundesokna have been equipped with water level and temperature loggers acquiring data with a very fine time resolution. These loggers collect fundamental data in order to understand the rapid changes caused by hydro-peaking. Additional instrumentation is planned and will be carried out as soon as the ordered instruments are available and ready for installation.

Detailed planning of the experiments to be carried out at Ims have been made and the experimental facilities been re-built and prepared for experiments. The facilities are expected to be ready in due time the Spring 2010.

Extensive literature reviews have been made for all the sub-activities on physical impacts, covering literature describing fundamental physical processes and practical applications of modelling tools for the purpose of assessing eco-system impacts from variable flows. Similarly, literature on biological impacts has been reviewed.

Finally, it should be mentioned that candidates for all the 3 PhD-positions have been contracted or identified (one of them contracted in 2010). One Post-doc candidate has been identified, and the contract is expected to be signed in March 2010.

3.4 HydroPEAK

Hydro power development for peaking and load balancing

HydroPEAK consists of 9 work packages, one for project management and coordination, and eight different studies on different topics. In seven of the work-packages a PhD study is a major component.

The activity in 2009 has mainly been limited to project mobilization and PhD candidate recruitment. Generally there have been a high number of applicants to the seven PhD positions, but not so many were well qualified. Most of the applicants were from outside Europe. At the end of the year four out of seven PhD positions have been filled. Three positions were still open at the end of 2009.

In **WP1 – Scenarios and dissemination**, some initial data collection started in 2009, but no results have been presented yet. This work-package will contain a number of activities related to the study of scenarios for future development of the power system in Europe.

The work in WP1 can be summarised as follows:

- It is initiated a preliminary literature study to map and describe the important premises for the scenario study with respect to matters that will affect the demand for, and price of, balancing power, directives from the EU that will promote/prevent further development and exploitation of the hydropower system, trends that affect/forms hydro powers reputation in Europe, and market factors constraining the future growth of transmission capacity between the Norway and the rest of Europe.
- Participation in the Research Council's "Technological meeting place" 14 October, where the theme was "Norway as EU's Energy Battery".
- Meeting with experienced people that can act as consultants and assure the quality of the work on scenarios.
- It is prepared a proposal for a framework for the scenario study.
- A detailed plan for implementation of the scenario study is under preparation. It is likely to be held 2 workshops with wide participation, in addition to the 3-5 working groups á 3-4 people that will be set up in order to work in more detail with selected issues.
- The project is involved in a special session entitled "Scenarios for power system development in Europe" during the conference "Hydropower and environmental effects of renewable energy" in Trondheim, 7.-8. June 2010. The results of the scenario study will be presented and discussed at this session. We are going to invite those who would otherwise have been appropriate participants at an international workshop to attend the conference/session.

In **WP2 – Hydrology**, the main objective is to develop better rainfall-runoff models for Nordic catchments, with hourly performance. The project activity has been limited to some initial studies and PhD candidate recruitment. A PhD candidate has been identified and will start in January 2010.

In **WP3 – Modelling power system**, the main activity will be a PhD project. A candidate has been recruited and started working in September. He has mainly worked on research plan and coursework.

In **WP4 – Pumped storage plants**, the main activity will be a PhD project. A candidate has been recruited and started working in September. She has mainly worked on research plan and coursework.

In **WP5 – Frequency and load governing**, the main activity will be a PhD project. Two qualified PhD candidates were recruited and offered the position, but unfortunately both withdrew from the position after a short time. At the end of 2009 there was still no new candidate in place.

In **WP6 – Flow fluctuations in tunnels**, the main activity will be a PhD project. A candidate was found and offered the position, to be starting in 2010.

In **WP7 – Flow fluctuations in rivers and lakes**, the main activity will be a PhD project. No suitable candidates have so far been identified. The recruitment work will continue in 2010.

In **WP8 – River ice and climate change**, the main activity will be a PhD project. A candidate was found and offered the position, to be starting in 2010.

3.5 GOVREP

GOVernance for Renewable Electricity Production

The project started in 2009, but only two out of a total of five work packages were initiated. This includes WP1 and WP3. WP2 with a historical-institutional analysis of the Norwegian licensing system for renewable electricity production will be initiated in 2010. WP4 includes a comparative assessment of relevant drivers and barriers for structural changes and innovation for renewable electricity production in Norway and Sweden. WP4 is directly based on findings in WP1, 2 and 3 and will not be initiated before 2011. Finally WP5 will propose a more feasible framework for improving governance for renewable electricity provision in Norway and Sweden. This will be conducted as a final delivery in 2012.

During 2009 a suitable PhD candidate was identified, but the project will not be initiated before January 1, 2010.

WP1 has a focus on Comparative assessments of the regulatory (both energy and environmental) frameworks and institutions in place for promoting renewable electricity production in Norway and Sweden.

Dialogue was established with the two industrial users of GOVREP: Statkraft and Agder Energy, and cases were suggested by both parties. Statkraft wanted a focus on the Helgeland region in which the Vefsna river is located – a river that recently has been included in the list of protected water courses. Interestingly, however, other smaller hydropower plants up till 10 MW are still realised – even in adjacent rivers to the Vefsna water course.

In close dialogue with Agder we selected a focus on two hydropower projects: Laudal and Iveland located in the Mandal – and Otra rivers respectively. A first brief fieldtrip was conducted in August, but the work in still pending and no scientific results were produced in 2009.

During the fall of 2009 more thorough studies were done in understanding the current procedures on environmental impact assessment related to revisions in licenses of existing hydropower plants. An explicit reference in this work is to relate current energy governance with the new governance structure in line with the implementation of the Water Framework Directive. Specified case studies, however, will not be undertaken until 2010. Work has also been initiated in developing an analytic framework for the project, and this will continue in 2010.

During 2009 a dialogue was established with the Swedish partner Stockholm Environment Institute (SEI), but due to the lack of finalizing the consortium agreement we could not specify any SEI deliveries. This has, however, been settled and GOVREP has initiated Swedish studies from January 1, 2010.

WP3 has a focus on technical and environmental assessment of the degree of coordination between renewable electricity production and environmental protective measures. The work has been conducted in close dialogue with WP1 and the focus on the Water Framework Directive. WP3 has also provided input to the ongoing studies of the Laudal project.

3.6 OPTIPOL

Optimal design and routing of power lines; ecological, technical and economic perspectives

From 2009 inclusive, NINA has received economic support for research on power lines and wildlife from the Research Council of Norway through the RENERGI programme.

With a grid close to 200 000 km overhead power-lines, the associated rights-of-way (ROW) affect huge land areas in Norway. The overall goal for the project is to develop predicting tools for optimal routing of power lines from an environmental perspective, and assess technical and economic solutions to minimize conflicts with wildlife and habitat conservation. Thus, the OPTIPOL rationale is based on the belief that the negative effects of electricity transmission and distribution can be reduced with respect to birds and mammals. OPTIPOL has several ambitious objectives, and is divided into sub-projects and specific tasks.

From the first of November 2009 a PhD-student became part of the project, a position that will be held for 4 years. The main objectives for the PhD-work is to evaluate how power line ROWs function as wildlife habitats by collecting data on animal usage, movement and behaviour in an area in Nord-Trøndelag crossed by a 420 kV transmission line. Fieldwork will be carried out to assess how habitat quality of power-line ROW´s can be enhanced by alternative pruning regimes. Five 1 km sections of power-line ROW´s will undergo alternative pruning techniques, whereas the remainder of the ROW will be cut in a traditional manner. Data collection will start before the experimental pruning and conventional clear-cutting is implemented. Prospectively, this will make it possible to compare animal's responses to power-line ROW´s before and after vegetation treatment.

Another focus will be small game species. Here we will assess population impact of bird mortality due to power-line collisions, relative to other human related mortality factors (primarily hunting) in gallinaceous birds (with capercaillie and black grouse as model species). The field-work is carried out in connection to the same 420 kV transmission line in Nord-Trøndelag, and an area of 30-50 km^2 will be censused over a four year period recording data on the population of capercaillie and black grouse by transect sampling of droppings for DNA identification in winter/spring, as well as the number and siting of leks. Simultaneously, the power line clear-felled corridor is searched for dead birds killed by colliding with the overhead wires using special trained dogs. A Wachtelhund, born in September 2009, is now being trained to locate dead birds in power-line corridors. By DNA identification of the dead birds (collisions victims and hunted birds) we will get estimates of different human-related mortality rates in the population. Annual survival estimates from the capture-recapture DNA-design will be used to compare the risk of collision mortality relative to the distance to power lines.

We are also working to identify topographic factors, vegetation structure etc., trigging frequent bird collisions, to predict high-hazard collision risk areas that should be avoided when power lines are built. A main focus will be on gallinaceous birds. Searches for injured or dead victims in or near power lines are necessary to assess the number of victims and estimating species-specific collision risks. To

identify topographic and external factors influencing the collision-risk factors, it is necessary to have detailed information on the place where collisions take place. Available data from earlier projects as well as new data will be the basement for modelling how birds use the terrain and thus enable – by means of GIS-tools – to predict what topographic structures and habitats that should be avoided when new power lines are routed.

We are also developing an online web application for registering dead bird data via Internet. We will target as many relevant users as possible and existing bird-collision data from various projects in NINA will also be imported into the database. A functional prototype of the web application is finished, and incorporates topographical maps, and the possibility of overlaying power-line maps. The work with a Least Cost Path (LCP) toolbox for optimal routing of power lines has started. A pilot LCP-GIS-toolbox has been developed and will be further developed in 2010.

The first stage of the work on power-line colour camouflaging and mitigating measures regarding bird collisions and electrocution are made as reviews studies and will be finalized in 2010. Guidelines for technical solutions to mitigate bird collisions and electrocution hazard have started and will be an important part of the work in 2010. The eagle-owl is used as a model species in connection to the studies of electrocution mitigating measures. The study includes use of GPS-satellite telemetry to see how the eagle owls use the pylons during hunting activities. This will also give data on eagle-owl movements and electrocution rate. In 2009 3 adult and 4 juvenile eagle owls were equipped with GPS-radio transmitters.

3.7 Tools

Tools for hydropower production

The scientific work in this project is postponed, and only project administration and project planning were done in 2009.

4 INTERNATIONAL COOPERATION

Building on well established relationships though previous and ongoing projects we will make agreements for international cooperation with carefully selected universities and institutes within the centre topics. Cooperation and knowledge exchange will be obtained through seminar and student exchange programs (master and PhD levels) and visiting researchers and integration will be ensured through membership in the CEDREN Scientific Committee. CEDREN will initially provide basic funding for establishing cooperation (e.g. travel and accommodation), whereas joint KMB and BIP-projects will be developed during the centre period. Cooperation will be organized along three axes, partly based on ensuring knowledge transfer from relevant geographic areas and excellent research groups, and partly to cover the major research areas (pillars) of CEDREN.

The trans-Atlantic axis relates to sustainable hydropower and will be organized by agreement with the Canadian "HydroNet - A national research network to promote sustainable hydropower and healthy aquatic ecosystems". The general objective of HydroNet – "to promote sustainable hydropower in Canada via a better understanding of the effects of hydroelectric facilities on aquatic systems" – is in close agreement with the CEDREN objectives on hydropower. The five major themes (Habitat productivity models, Fish passage, Reservoirs, Flow regime and Winter and ice dynamics) are headed by internationally recognized eminent scientists, supported by 28 scientists from the major universities and research institutes in Canada. If HydroNet is not funded, CEDREN will make separate agreements with the major network partners.

The European hydropeaking axis is represented by the University of Life Sciences and Natural Resources (BoKu), Wien, Austria. BoKu was selected based on their excellence within the field of hydropower development and environmental impacts. BoKu has a wide experience in benthic and fish ecology, management of running waters, river conservation and water protection as well as within hydrological modelling, water resources planning, river restoration, hydraulic engineering and hydropower utilization, hydraulic structures and simulation for process- and energy engineering. This competence will be specially focused on the common Norwegian and Austrian challenges related to hydropower for peaking and load balancing.

The Nordic axis will be established to exploit the similarities of challenges and solutions for energy systems within the Nordic countries. Based on established cooperation we will establish a Nordic network consisting of KTH (Royal Institute of Technology, Stockholm) with strong competence in hydraulic and hydrological sciences, SLU (Swedish University of Agricultural Sciences) with particular competence on ecological effects of hydropower and biofuels, FGFRI (Finnish Game and Fisheries Research Institute) with analogous competence but with emphasis on ecosystem services (game and fisheries), and NERI (National Environmental Research Institute, University of Aarhus), a broadly oriented institute responsible for providing the technical and scientific foundation for policy decisions related to nature and environment in Denmark, including a strong competence on environmental impacts of wind power.

Besides these three axes of cooperation and the affiliated institutions and scientist, CEDREN scientists will work together with several other international partners on individual centre projects, KMBs, BIPs and other projects.

5 RECRUITMENT

The projects BirdWind and EnviDORR were already started when CEDREN was established. BirdWind has already one PhD student and one Post-doc position, and EnviDORR has 3 PhD students and 1 Post-doc position.

12 PhD fellowships were announced in June 2009. In total there were ca. 180 applications, of which only 5 were Norwegians and a few were women. In general, it is very difficult to recruit qualified Norwegian applicants.

Due to the late formal start-up of the centre, only 5 were recruited in 2009. In addition, 3 more were offered engagements starting in early 2010. One of these 8 candidates is Norwegian, and 5 are women.

The last 3 positions were announced again in late 2009, and they are still open. If no qualified applicants can be found for the remaining PhD positions, Post-Doc positions may be offered instead.

6 COMMUNICATION AND DISSEMINATION

6.1 Strategic planning

The main activity in CEDREN's communication and dissemination in 2009 was to initiate the process of developing a communication strategy and communication plans for the centre and the projects. The Centre Management Group (CMG) was gathered for this purpose in May 2009. Important was also different discussions of operational and strategic matters at the regular CMG-meetings. However, the progressional planning had to await establishment of the consortium, meaning the first General Assembly and the first board meeting in September, and the final approval of the consortium agreement in November 2009.

Several meetings and seminars for the Board and the CMG have refined the vision and strategic objectives of the centre, and a strategy document will be addressed to the Board meeting in April 2010.

6.2 Operational deliverables

Beside the planning process the centre activities have required different deliverables relevant to the communication and dissemination objectives:

- graphic profile and templates for CEDREN documents
- temporary web-pages were established during spring 2009 (we are currently refining the web and making it more functional and dynamic)
- media surveillance system is established (summary of CEDREN publicity is enclosed)
- CEDREN brochure in Norwegian (approximately 800 copies are distributed)
- fact sheet in Norwegian
- powerpoint presentations in Norwegian and English
- eRoom collaborative solution were established to facilitate the internal communication
- eRoom also contains a publication database which will be fully implemented soon

7 ATTACHMENTS

7.1 Personnel

Key Researchers

Name	Institution	Main research area
Atle Harby	SINTEF	Management, EnviDORR, EnviPEAK, HydroPEAK, GOVREP
Arnt Ove Eggen	SINTEF	Management
Tor Haakon Bakken	SINTEF	Management, EnviDORR, EnviPEAK, HydroPEAK, GOVREP
Audun Ruud	SINTEF	Management, HydroPEAK, GOVREP
Birger Mo	SINTEF	Management, EnviDORR, Tools
Knut Alfredsen	SINTEF	Management, EnviPEAK
Julian Sauterleute	SINTEF	EnviDORR, EnviPEAK
Håkon Sundt	SINTEF	EnviDORR, EnviPEAK
Lena Tøfte	SINTEF	EnviDORR, EnviPEAK, HydroPEAK
Sjur Kolberg	SINTEF	EnviDORR, HydroPEAK
Kolbjørn Engeland	SINTEF	EnviDORR, Tools
Turid Follestad	SINTEF	EnviDORR, Tools
Tommi Linnensaari	SINTEF	EnviPEAK
Morten Stickler	SINTEF	EnviPEAK
Jo H Halleraker	SINTEF	EnviPEAK
Eivind Solvang	SINTEF	HydroPEAK
Maria Catrinu	SINTEF	HydroPEAK
Ingeborg Graabak	SINTEF	HydroPEAK
Luz Tenorio	SINTEF	HydroPEAK
Jørgen Kjetil Knudsen	SINTEF	HydroPEAK, GOVREP
Gerd B. Jacobsen	SINTEF	GOVREP
Hallvard Faremo	SINTEF	OPTIPOL
Niklas Magnusson	SINTEF	OPTIPOL
Steinar Refsnæs	SINTEF	OPTIPOL
Magne Runde	SINTEF	OPTIPOL
Arne Haugstad	SINTEF	Tools

Name	Institution	Main research area
Norunn Myklebust	NINA	Management
Oddmund Rønning	NINA	Management
Kjetil Bevanger	NINA	Management, BirdWind, OPTIPOL
Torbjørn Forseth	NINA	Management, EnviDORR, EnviPEAK
Finn Berntsen	NINA	BirdWind
Stig Clausen	NINA	BirdWind
Øystein Flagstad	NINA	BirdWind
Arne Follestad	NINA	BirdWind
Pernille Lund Hoel	NINA	BirdWind
Lars Johnsen	NINA	BirdWind
Yngve Steinheim	NINA	BirdWind
Ole Reitan	NINA	BirdWind, EnviPEAK
Duncan Halley	NINA	BirdWind, EnviPEAK
Roelof May	NINA	BirdWind, OPTIPOL
Espen Lie Dahl	NINA	BirdWind, OPTIPOL
Hans Chr. Pedersen	NINA	BirdWind, OPTIPOL
Roald Vang	NINA	BirdWind, OPTIPOL
Pål Kvaløy	NINA	BirdWind, OPTIPOL
Frank Ole Hanssen	NINA	BirdWind, OPTIPOL
Torgeir Nygård	NINA	BirdWind, OPTIPOL
Arne Jensen	NINA	EnviDORR
Richard Hedger	NINA	EnviDORR
Nils Arne Hvidsten	NINA	EnviDORR
Ola Diserud	NINA	EnviDORR
Peder Fiske	NINA	EnviDORR
Eva Thorstad	NINA	EnviDORR
Line Sundt-Hansen	NINA	EnviDORR
Maxim Teichert	NINA	EnviDORR
Anders Foldvik	NINA	EnviDORR
Ola Ugedal	NINA	EnviDORR, EnviPEAK
Anders Finstad	NINA	EnviDORR, EnviPEAK
Ole Ravndal	NINA	EnviDORR, EnviPEAK
Jiska Van Dijk	NINA	EnviPEAK
Roger Meås	NINA	EnviPEAK
Zlatko Petrin	NINA	EnviPEAK
Øystein Aas	NINA	EnviPEAK
Jan Ove Gjershaug	NINA	OPTIPOL
Henrik Brøseth	NINA	OPTIPOL
Karl Otto Jacobsen	NINA	OPTIPOL
Morten Heim	NINA	OPTIPOL

Name	Institution	Main research area
Gundula Bartzke	NINA	OPTIPOL
Sigbjørn Stokke	NINA	OPTIPOL
Ånund Killingtveit	NTNU	Management, HydroPEAK
Knut Alfredsen	NTNU	EnviDORR
Hans Petter Fjeldstad	NTNU	EnviDORR
Jo Vegar Arnekleiv	NTNU	EnviDORR, EnviPEAK
Gaute Kjærstad	NTNU	EnviPEAK
Lars Rønning	NTNU	EnviPEAK
Torbjørn Nielsen	NTNU	HydroPEAK
Gerard Doorman	NTNU	HydroPEAK
Svein Jakob Saltveit	LFI	EnviDORR, EnviPEAK
Jan Heggenes	LFI	EnviPEAK
Åge Brabrand	LFI	EnviPEAK
John Brittain	LFI	EnviPEAK
Haakon Thaulow	NIVA	GOVREP
Dag Berge	NIVA	EnviPEAK
Bjørn Barlaup	UNI Miljø LFI	EnviDORR, EnviPEAK
Helge Skoglund	UNI Miljø LFI	EnviDORR, EnviPEAK
Ulrich Pulg	UNI Miljø LFI	EnviDORR, EnviPEAK
Tore Wiers	UNI Miljø LFI	EnviDORR, EnviPEAK
Sven Erik Gabrielsen	UNI Miljø LFI	EnviDORR
Anker Halvorsen	UNI Miljø LFI	EnviPEAK
Ole Sandven	UNI Miljø LFI	EnviPEAK
Ole Brekke	UNI Rokkan	GOVREP
Svein Ivar Angell	UNI Rokkan	GOVREP

Postdoctoral researchers with financial support from the Centre budget

Name	Nationality	Period	Sex	Topic
Line Sundt-Hansen	Norwegian	2011–2013	F	Individual based Atlantic salmon population modelling for ecological forecasting based on climate scenario
Roel May	Dutch	2008–2010	M	Spatial assessment of avian collision risks at the Smøla on-shore wind farm

PhD students with financial support from the Centre budget

Name	Nationality	Period	Sex	Topic
Espen Lie Dahl	Norwegian	2009–2012	M	Population dynamics in white-tailed sea eagle at a wind-farm area in coastal Norway
Hans Petter Fjeldstad	Norwegian	2007–2011	M	Salmon migration challenges and solutions in regulated rivers
Maxim Teichert	German	2007–2011	M	Effects of river discharge on salmonid fish production in regulated rivers
Helge Skoglund	Norwegian	2001–2011	M	Spawning and early fry survival in relation to environmental factors in regulated rivers
Joachim Dahl Jensen	Norwegian	2009–2012	M	Long term hydro scheduling with high shares of new renewable generation
Eve Cathrin Walseth	Norwegian	2009–2012	F	Investigate performance characteristics of reversible pump turbines in both turbine, pump and condenser modes of operation with focus on stabile frequency governing
Michael Puffer	German	2009–2012	M	Density dependent habitat use and performance of salmonid fishes in regulated rivers
Gundula Bartzke	German	2009–2012	F	Effects power-line rights-of-way on habitat use, movement and behaviour of wildlife and recommendations for improved vegetation management

Master degrees

Name	Sex	Topic
Pernille Lund-Hoel	F	Do wind-power developments affect the behaviour of White-Tailed Sea Eagles on Smøla?
Julian Sauterleute	M	Characterisation of rapid fluctuations in flow and assessment of fish stranding risk in rivers
Morten Asbjørnsen	M	The effects of hydro-peaking operation on decomposition and grazing rates
Steinar Tronhus	M	The effects of hydro-peaking operation on decomposition and grazing rates

7.2 Annual accounts

The total financing in 2009 was MNOK 18 835, of which MNOK 3977 was grant from the Research Council of Norway through CEER, MNOK 6954 was grant from the Research Council of Norway through RENERGI, and MNOK 7905 came from the consortium partners.

		Type of partner**	BirdWind	EnviDORR	EnviPEAK	HydroPEAK	GOVREP	OPTIPOL	Tools	Equipment	Adm.	Total budget
	Type of Research*		F	F	F	F	F	F	I			
	Incentive effect****		1101	1101	1101	1101	1101	1101	1101			
	Bonus Category***		100	100	100	100	100	100	65			
Funding	RCN Grant FME				1.074	346	604	735	83		1.135	3.977
	RCN Grant RENERGI				1.878	605	1.056	1.285	146		1.984	6.954
	Host*****				1.193	299	990	249	146		0	2.877
	Other Public				454	75	0	892	0		0	1.421
	Other Private		62	331	783	236	412	450	50		1.283	3.607
	Skatte-FUNN											
	1 SINTEF	R			1.193	299	990	249	146			2.877
	2 NINA	R			248			892	0			1.140
	3 NTNU	R				75						75
	4 Lab for ferskvannsøkologi	R			79							79
	5 NIVA	R										
	6 UNIFOB AS	R			126							126
	7 Agder Energi AS	L		65	59	15	44	26	3		114	324
	8 BKK AS	L		85	75	5	8	10	1		90	274
	9 E-CO Vannkraft	L		85	66	21	37	45	5		65	324
	10 Eidsiva Vannkraft	L			28	9	16	19	2		49	124
	11 Energi Norge	P		43	32						136	211
	13 Norsk Hydro Produksjon AS	L			38	12	21	26	3		37	137
	14 ICH	R										
	16 Sira-Kvina kraftselskap	L			47	15	27	32	4		46	171
	17 Statkraft AS	L	20	10	393	147	233	259	29		675	1.766
	18 Statnett	L			28	9	16	19	2		28	103
	19 TrønderEnergi	L			9	3	5	6	1		9	34
	20 Direktoratet for naturforvaltning	P	42	44	7		5	7			34	139
	21 NVE	P			0	0	0	0	0		0	0
	Total state aid		0	0	2.952	951	1.659	2.019	229		3.119	10.930
	Total funding		62	331	5.382	1.561	3.061	3.611	426		4.402	18.835
	State aid/total funding				55 %	61 %	54 %	56 %	54 %		71 %	58 %

The total cost in 2009 was MNOK 18 835, of which MNOK 10 943 came from the host institution, MNOK 6633 came from the research partners, and MNOK 1260 came from the industry partners.

		Type of partner**	BirdWind	EnviDORR	EnviPEAK	HydroPEAK	GOVREP	OPTIPOL	Tools	Equipment	Adm.	Total budget
	Type of Research*		F	F	F	F	F	F	I			
	Incentive effect****		1101	1101	1101	1101	1101	1101	1101			
	Bonus Category***		100	100	100	100	100	100	65			
Funding	RCN Grant FME				1.074	346	604	735	83		1.135	3.977
	RCN Grant RENERGI				1.878	605	1.056	1.285	146		1.984	6.954
	Host*****				1.193	299	990	249	146		0	2.877
	Other Public				454	75	0	892	0		0	1.421
	Other Private		62	331	783	236	412	450	50		1.283	3.607
	Skatte-FUNN											
	1 SINTEF	R			3.234	809	2.685	676	395		3.144	10.943
	2 NINA	R			777			2.796			987	4.560
	3 NTNU	R			100	802					134	1.036
	4 Lab for ferskvannsøkologi	R			365							365
	5 NIVA	R			40		42					82
	6 UNIFOB AS	R			436		85				69	590
	7 Agder Energi AS	L		65	21	2	23				77	187
	8 BKK AS	L		85	61						76	223
	9 E-CO Vannkraft	L		85								85
	10 Eidsiva Vannkraft	L									22	22
	11 Energi Norge	P		43	32						136	211
	13 Norsk Hydro Produksjon AS	L										0
	14 ICH	R										0
	16 Sira-Kvina kraftselskap	L										0
	17 Statkraft AS	L	20	10	15	25	20				305	395
	18 Statnett	L										0
	19 TrønderEnergi	L										0
	20 Direktoratet for naturforvaltning	P	42	44	7		5	7			34	139
	21 NVE	P										0
	Total state aid		0	0	2.952	951	1.659	2.019	229	0	3.119	10.930
	Total cost		62	331	5.087	1.639	2.859	3.479	395	0	4.982	18.835
	State aid/total cost				58 %	58 %	58 %	58 %	58 %		63 %	58 %

7.3 Publications

7.3.1 Journal Papers

Title	Author	Journal
Addition of spawning gravel - a means to restore habitat of Atlantic salmon (Salmo salar L.), and...	Barlaup, BT., Gabrielsen, SE., Skoglund, H., Wier	24 2008, pp. 543-550

7.3.2 Published Conference Papers

Title	Author	Conference
Spatial assessment of white-tailed sea eagle collision risk at the onshore wind-power plant on the island of Smøla	May, R., Nygård, T	2nd European Congress of Conservation Biology. Conservation biology and beyond: from science to practice. Czech University of Life Sciences, Prague. September 1-5, 2009
Juvenile White-tailed Sea Eagles' (Haliaeetus albicilla). Movement Patterns at Smøla Wind-farm in Norway Determined by Satellite Telemetry	Nygård, T., Bevanger, K., Dahl, E. L., Flagstad, Ø., Follestad, A., May, R., Reitan, O., Schulze, J.	Raptor Research Foundation annual meeting. Pitlochry, Scotland. 30. Sept. - 3. Oct. 2009
The use of satellite transmitters in eagle research in Norway	Nygård, T., Jacobsen, K.-O., Dahl, E. L.	Microwave Telemetry, Inc. 2009 bird and fish tracking conference. Elliot City, Maryland, USA. 24-26 March 2009

7.3.3 Reports

Title	Author	
Pre- and post-construction studies of conflicts between birds and wind turbines in coastal Norway (BirdWind) – Progress Report 2009	Bevanger, K., Berntsen, F., Clausen, S., Dahl, E.L., Flagstad, Ø., Follestad, A., Halley, D., Hanssen, F., E., Hoel, P.L., Johnsen, L., Kvaløy, P., May, R., Nygård, T., Pedersen, H.C., Reitan, O., Steinheim, Y., Vang, R.	NINA Report 505. 70 pp.
Optimal design and routing of power lines; ecological, technical and economic perspectives (OPTIPOL) – Progress Report 2009	Bevanger, K., Bartzke, G., Brøseth, H., Gjershaug, J.O., Hanssen, F., Jacobsen, K.-O., Kvaløy, P., May, R., Nygård, T., Pedersen, H.C., Reitan, O., Refsnæs, S., Stokke, S. & Vang, R.	NINA Report 504. 46 pp.

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