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PROJECT SYNOPSES



SUSTAINABLE DEVELOPMENT, GLOBAL CHANGE AND ECOSYSTEMS

Table of Contents

Foreword	5
Photovoltaics	7
Thin Film Technologies.....	8
New and Emerging Concepts.....	20
Wafer-Based Silicon.....	30
Pre-normative Research and Co-ordination Activities.....	36
Biomass	41
Biofuels for Transport.....	42
Energy from Crops.....	46
Gasification and H ₂ -production.....	50
Biorefinery.....	64
Combustion and Cofiring.....	68
Pre-normative Research and Co-ordination Activities.....	74
Other Renewable Energy Sources and Connection to the Grid	83
Wind.....	84
Geothermal.....	90
Ocean.....	98
Concentrated Solar Thermal.....	106
Connection of Renewable Energy Sources to the Grid.....	118
Socio-economic Tools and Concepts for Energy Strategy	133
Economic and Environmental Assessment of Energy Production and Consumption.....	134
Social Acceptability, Behavioural Changes and International Dimension related to Sustainable Energy RTD.....	140
Annexes	155
List of Country Codes.....	156
List of Acronyms.....	157
Energy Units Conversion.....	158

Coordinating the Prediction of Renewable Offshore Energy Production

OBJECTIVES

POW'WOW is a new project trying to harmonise approaches to wave and wind modelling offshore, helping the short-term forecasting and wake research communities by establishing virtual laboratories, offering specialised workshops, and setting up expert groups with large outreach in the mentioned fields.

Two Virtual Laboratories, one for offshore wake modelling, the other one for short-term forecasting, will be set up. Two guides on best practices will be written, one on short-term forecasting (bringing the experiences of high wind penetration countries to those with little wind power) and one for wake modelling. In the end, this Coordination Action will also support preparation of further initiatives such as a Network of Excellence or an Integrated Project.



Challenges

Climate change is related to the way we generate electricity. As part of the Kyoto effort to reduce the emissions of greenhouse gases, the European Union has an overall target of 12% of energy (22% electricity) from renewables by 2010.

Wind energy is the fastest growing renewable energy source in the European Union. By 2003 more than 28,000 MW of wind energy capacity had been installed in Europe (600 MW offshore). The wave resource in European waters is even larger: 120-190 TWh/year (offshore) and 34-46 TWh/year (nearshore). Yet, despite many research efforts from the 1970s onwards, relatively little installed capacity exists, although prototypes have been developed in many countries. The proposed project seeks to integrate further the wind and wave energy communities to maximise the research effort on resource assessment and to utilise expertise from wind energy short-term forecasting and wave energy resource assessment for optimal planning and operation of offshore energy technology.

While some of the project resources go into specialised activities supporting research in the three fields individually (wave power, short-term prediction of wind power, and offshore wakes

behind turbines and wind farms), it shall also be seen how to better integrate the long-term and short-term prediction of offshore energy resources from a modelling standpoint.

Project Structure

The project is largely structured around three topical work packages, for wave energy (both long-term and short-term), short-term prediction of wind power (both onshore and offshore: long-term prediction of wind resources is only a problem in complex terrain, which is too dissimilar to the other activities to be included here), and wakes behind offshore turbines and wind farms. Two additional work packages deal with management and dissemination activities and future work. The dissemination in the field of short-term forecasting also includes connections to colleagues outside Europe.

Expected Results

A number of workshops are envisaged in quite specialised areas, usually leading to a document detailing out the progress in the field. One is a cross-cutting workshop with the aim of cross-fertilising the separate approaches in the offshore meteorology community, integrating wind and wave resource modelling. Another workshop is planned on integrating and implementing wake models in short-term forecasts of wind power. A third workshop is already in preparation for October 25, 2006, on the best practice in short-term prediction of wind power, where high-penetration utilities can present their experiences with the day-to-day use of short-term forecasting tools to utilities quite new to the game. The results of this workshop should go into a document detailing the best utility practice in short-term forecasting.

In the fields of wave modelling and short-term forecasting, two expert groups are being set up, for support of politics, but also for dissemination activities outside Europe. The expert groups will also identify potential new research topics for funding agencies.

One problem hindering progress, especially in the economically sensitive field of offshore wind power but also in wind power in general, is the



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EC Baltic Renewable Energy Centre – PL
Energy & meteo systems – DE
INETI – PT
Institute of Accelerating Systems
and Applications – GR
Institut für Solare
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Risoe National Laboratory – DK
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Status

ongoing



lack of good accessible data. This will be taken care of by the establishment of two Virtual Laboratories, one for short-term forecasting, the other one for wakes. The idea is, in part, to take some of the cumbersome work of data acquisition out of the research projects themselves and put it here, and in part to have common evaluation criteria and common evaluations of the work, and being able to compare one's own research with the best (and worst) in the field. This idea is somewhat modelled on two very successful efforts, one being www.winddata.com and the other one the Anemos case studies and benchmarking process. In winddata.com, quality-checked measurement campaigns (of usually short duration) have been put into a central repository in a common data format, so that institutes that have signed up to it can download the data and use it. The data spans 165,000 hours from 57 sites and is used for many different purposes, ranging from resource assessment to structural high-resolution measurements on actual wind turbines for load cases. The other case to model on is the Anemos benchmarking exercise, where in all 11 different models were fed with the same NWP data for six wind farms in Europe. One institute (CENER) did the common evaluation and presented the results in London at the EWEC conference in November 2004. One important aspect of this was the development of a common evaluation procedure and common evaluation criteria, led by IMM. The details of

access to data, the potential worries of the data owners (wind turbine data and NWP) about making their data public, and the exact demands for publication from ViLab participants will have to be decided on during setting-up of the ViLab.

Progress to Date

Currently, the expert groups are established, and work goes on towards establishing the Virtual Laboratories. Also, the first workshop has been announced on the website (powwow.risoe.dk/BestPracticeWorkshop.htm). It will be held in conjunction with the 6th Workshop on Large-Scale Integration of Wind Power and Transmission Networks for Offshore Wind Farms in Delft (see offshoreworkshop.org). The date is October 25, 2006. Please see the website for registration details.

Ocean Energy, Wave and Tidal Power

OBJECTIVES

The main objectives of the Co-ordinated Action on Ocean Energy are to enable cooperation between developers and interested parties in the sector of ocean energy, to promote and disseminate knowledge on ocean energy technologies, to develop a common knowledge base for coherent development R&D policies, to bring a coordinated approach within key areas of ocean energy R&D, and to provide a forum for the longer-term marketing of promising research deliverables.

The project also addresses issues like revising and implementing guidelines and standards for monitoring and presenting the performance of ocean energy systems, and guidelines and standards related to safety of structure, personnel and electrical systems.

Challenges

Ocean energy can in the future replace a significant part of the fossil fuel used today if the principles for conversion can be successfully demonstrated and put into mass production. Presently only a few systems are being tested on a pre-commercial scale and providing initial practical experience.

Within the Co-ordinated Action on Ocean Energy, this new knowledge and the research results emerging on wave and tidal technologies are disseminated, promoted and shared. The partners must agree on definitions, standards in design, costing, and be ready to present the performance results of the systems involved. This approach is expected to provide comparable presentations of different methodologies and accelerate the development of ocean energy systems.

Project Structure

The Co-ordinated Action on Ocean Energy includes 41 partners from 15 countries. The partners of this co-ordination action are the leading force in the field of ocean energy, while the SME organisations are pioneers on the road to commercialisation of these systems. An additional 20 partners have registered as associates during the first year.

The project is organising five interactive workshops over a three-year project period. The themes for the five workshops are:

- Numerical modelling and tank testing
- Components and power take-off
- Structural design
- Performance assessment
- Environmental impact.



The workshops provide a forum for the different research organisations and the fledgling ocean energy industry to interact and co-ordinate ongoing R&D efforts in the field of wave and tidal energy on a European and international level. New academic knowledge can be shared and disseminated between all interested parties, and promising methodologies and technologies can be transferred to the market.



Expected Results

The Co-ordinated Action is expected to promote and disseminate promising methodologies and technologies for the conversion of ocean energy into electricity and further generate awareness among a wider public.

Frequent workshops attended by the partners involved, combined with exchange of personnel, are expected to generate clusters of research groups that will focus on research activities of common interest:

- Dissemination and promotion of ocean energy
- Roadmap for ocean energy development
- Terminology definitions
- Folder on ocean energy technologies
- Establishment of an European Ocean Energy Association.

The initiative to form a European Ocean Energy Association has been taken to help promote development toward implementation and commercial exploitation.

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502701

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39 months

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IT Power – GB
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Teamwork Technology BV – NL
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University of Edinburgh – GB
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University of Lancaster – GB
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Status
ongoing

Progress to Date

The main objective of bringing all the partners together has been successfully met. The project kick-off meeting was held one month after the project started in November 2004 in Copenhagen, Denmark. All partners attended the objectives workshop planning sessions. As an additional chance to get to know each other, the partners were invited to attend a workshop on grid connection arranged by IEA-OES, as well as a technical tour of the Wave Dragon experiment in Nissum Bredning.



WP 1: Numerical and experimental modelling, 4-5 April 2005

The first workshop was held at Aalborg University, Denmark. The topic of the workshop was covered by a number of presentations on new modelling techniques and examples of testing ocean energy systems on different scales. The workshop provided the opportunity for ocean energy developers to share expertise and help in device modelling and testing with the university partners of the project.



Pre-conference workshop to the 6th European Wave Energy Conference, 30 August 2005

The partners in the CA-OE project arranged a pre-conference workshop before the 6th European Wave Energy Conference in order for them to meet and promote the co-ordinated action with a wider audience.

The initiative of forming a European Ocean Energy Association was taken following this pre-conference workshop to help promote development aimed at implementation and commercial exploitation. The association has the web-address: www.eu-oea.com.

WP 2: Component Technologies and Power Take-off, 1-2 November 2005

The second workshop was held in Upsala, Sweden. The topic of this workshop was covered by a number of presentations on different power take-off systems, such as linear generators transforming the oscillating forces and movements directly into electricity, oil hydraulic systems as used in the Pelamis project, water turbines as used in the Wave Dragon project, and air turbines as used in OWCs such as the Picoplant and the Limpet system. Presentations on other components such as moorings were also given and discussed.

WP 3: System design, Construction, Reliability & Safety, 29-30 March 2006

The third workshop was arranged by Ecofys in Amsterdam. The topic of this workshop was, in contrast to the previous workshops, covered in a more interactive way. Key speakers from DNV and Germanischer Lloyd were invited to the workshop to give presentations on the new standards drafted for ocean energy, followed by a few presentations illustrating the issues. Group work then followed, and the partners exchanged their experiences in relation to the topic and provided focused input on priorities for further R&D.

Sustainable Economically Efficient Wave Energy Converter

OBJECTIVES

The general objective of SEEWEC is to assist in the development of a second-generation FO³ wave energy converter through extensive use of the experience from monitoring a 1:3 laboratory rig (Buldra), the single system test station (SSTS) and a first-generation 1:1 prototype.

The project will focus on robust cost-effective solutions and design for large-scale (mass) manufacturing. The long-term objective is to be able to produce electricity at a cost competitive to electricity from other renewable sources. The first step is to become competitive to offshore wind.

Challenges

To arrive at an economically efficient wave energy converter design, and more specifically at an optimised prototype, is a complicated task. Several issues have to be investigated, as there is:

- A technological risk: although the technology is proven in scale tests, it still has to be proven in full scale in real-sea conditions.
- A commercial risk: the commercialisation will be dependent on cost-effective production and operation. In order to overcome this, each optimisation found within this project will be tested for its financial viability as part of the whole outcome of this project.
- A political risk: a commercial development is dependent on political support to introduce new technologies to the market. In the case of renewable energy systems, there is a strongly positive attitude at a European level on promoting renewable energy systems.

Project structure

The initial work on the FO³ wave energy converter started in 2001, with the objective of developing a cost-effective and environmentally friendly technology for wave energy conversion. Initial research was conducted at the Department of Mathematics (University of Oslo) and at the Norwegian University of Science and Technology (NTNU) in Trondheim.



1:20 model in the wave tank with 21 point absorbers/eggs installed on a floating platform.

A project group was established and key patents were filed in 2003. Following conceptual design and theoretical modelling, the general design was developed. A 1:20 scale model of the FO³ was tested in the wave tank of the Ocean Basin Laboratory of Sintef in Trondheim in early-2004. The scale model was tested both in operational conditions and for survival/extreme sea conditions. The tests confirmed the production concept.



1:3 laboratory rig 'Buldra'

The 1:3 laboratory rig (Buldra) started sea trials in February 2005. A single system test station (SSTS) will be monitored from spring 2006 onward. The prototype full-scale first-generation device is planned to be launched by autumn 2007.

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019969

Duration
36 months

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Norwegian University of Science and Technology – NO
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Status
ongoing



Prospective farm of F03s

Expected results

All three devices are expected to be used for extensive monitoring and testing during the SEEWEC project. The results of these tests will provide the project team with valuable input for the design of the second generation of the converter.

The SEEWEC project has been structured around 11 work packages. Some work packages are initial tasks (preparing and supporting), others are synthesising and concluding, the final work package exploiting and disseminating. The core work packages are what can be called scientifically and technologically productive.

The SEEWEC consortium involves 11 partners from five EU members (Belgium, the Netherlands, Portugal, Sweden and the UK) and one associated country (Norway). As a group, the partners have relevant experience of field testing, local sea conditions, material design and development, wave impacts on structures, behaviour and interference of structures in open seas, power conversion systems, manufacturing of materials and marine construction.

The SEEWEC project aims at gaining extensive knowledge to provide optimal input for the manufacture of a second generation of the wave energy converter, to prepare for large-scale production and commercial exploitation.

Pioneering Technology for Bulk Generation of Wave Power

OBJECTIVES

This project will realise the Wave Dragon technology and develop it from the tested all-steel-built 20 kW prototype to a full-size composite-built 4-7 MW unit and, by comprehensive testing, validate its technical and economic feasibility.

The RTD part of the project will develop Wave Dragon's energy-absorbing structure, the low head turbine power take-off system and the control systems; develop cost-effective construction methods and establish the optimal combination of in situ cast concrete, post-stressed reinforcement and pre-stressed concrete elements; develop a cost-effective 250-440 kW hydro turbine system; demonstrate reliable and cost-effective installation procedures and O&M schemes; and establish the necessary basis for design codes/recommendations for offshore multi-MW devices.

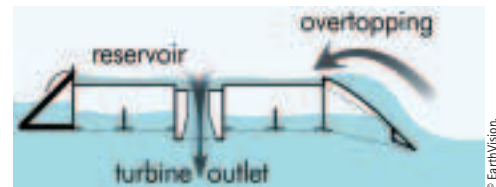
Challenges

The Wave Dragon is an offshore wave energy converter of the overtopping type. The development work is, to a large extent, built on proven technologies and Wave Dragon is by far the largest wave energy converter known today. Each unit will have a rated power of 4-11 MW or more, depending on how energetic the wave climate is at the deployment site. In addition to this, Wave Dragon - due to its large size - can act as a floating foundation for MW wind turbines, thus adding a very significant contribution to annual power production at a marginal cost.

By using the overtopping principle for energy absorption, there is no upper limit on device size and rated power for Wave Dragon, as opposed to technologies that rely on moving bodies etc. (like buoys, hinged bodies and oscillating water columns) for energy absorption.

Wave Dragon's competitive advantage lies in its scale and hence capital cost: only nine units are required to make a 100 MW power station, compared to 100-1000 units required by most technologies, and the few moving parts improve reliability and reduce maintenance costs. The design simply reapplies a well-proven existing technology that has been around for 80 years. Wave Dragon is essentially a floating hydro-electric dam.

Developers of wave energy converters face a series of major challenges: first we have to develop machinery that can operate and survive in this very tough environment and, secondly, we have to optimise operation and maintenance



The Wave Dragon technology absorbs wave energy by overtopping water. Power is generated when water from the above mean water level storage reservoir is drained back to sea through traditional hydro propeller turbines.

systems to make wave power plants a viable solution. Wave energy converters have to compete with other renewable energy technologies. It has become obvious that wave power can be much cheaper than, for instance, photovoltaic power and there are good reasons to believe that in a few years it will be a serious competitor to offshore wind power.

Project structure

This project is organised in seven operative work packages, each with clearly defined deliverables:

- Scaling-up/design – Development and design of full-size power producing unit and sub-systems
- Construction, manufacturing and deployment
- Establishment of monitoring system, operation and maintenance
- Design parameter analysis
- Power production and control strategy
- Life cycle / Environmental Impact Assessment and socio-economic aspects
- Dissemination and exploitation

All the R&D-related work packages are covered by this project. Work package 2 – construction and deployment – is funded from other sources.

This project will realise the Wave Dragon technology, developing it from the tested all-steel-built scale 1:4.5 prototype to a full-size composite-built 4-7 MW unit and, by comprehensive testing, validate its technical and economic feasibility.



The Wave Dragon is a floating device consisting of two parabolic arms that reflects and enlarges waves towards a ramp. Wave energy is absorbed passively by overtopping water that is collected and short-term stored in a reservoir behind the ramp.

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36 months

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NIRAS AS – DK
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Warsaw University of Technology – PL
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Status
ongoing

The R&D activities will:

- Develop the optimal way to construct the Wave Dragon, taking into account the large physical size, the facilities and skills available and also the techniques required to combine steel and reinforced concrete to make up the structural form we require.
- Finalise the development of the power takeoff system consisting of simplified hydro turbines, advanced inverter technology and permanent magnet synchronous generator technology, in combination with an advanced control system never tested in full scale before.
- Demonstrate that the Wave Dragon hull and reflectors can be constructed with a combination of reinforced concrete and steel.
- Demonstrate the deployment of the full-scale device and document its basic hydraulic behaviour in relatively calm water before the final deployment.
- Develop an operation and maintenance scheme and operate a wave energy device in MW-size using an advanced control system and a new innovative power take-off system.
- Run an advanced test programme on the device in order to gain information not only for the documentation of its behaviour but also to establish scientific knowledge far beyond the state-of-the-art today.
- Establish the socio-economic impact of Wave Dragon such as job creation, life cycle assessment and environmental impact related to a MW-size wave energy device.

All R&D activities in this project will be carried out in relation to a 7 MW Wave Dragon device that will be constructed and deployed off the South-West Welsh coast.

During long-term testing in a real-sea environment, the Wave Dragon prototype has progressed to the point where it is now producing electricity 80% of the time. This real-sea testing has also proven its seaworthiness, floating stability and power production potential. Operation of the device in a harsh offshore environment has led to a number of smaller component failures: all of these have been investigated and technical solutions have been found, thus preventing

costly (in both time and money) problems from occurring in the future. The work done up to now has confirmed that the performance predicted on the basis of wave-tank testing and turbine model tests will be achieved in a full-scale prototype.

This project will develop the technological basis for a commercially viable solution to the bulk generation of renewable power and thus add to Europe's ability to tackle the problems of security of supply and greenhouse gas emissions.

Expected results

The quantitative objectives refer to a 24 kW/m wave climate:

- Higher energy production of each unit to a total of 10 GWh/y, resulting in a total improvement of 12%; where 5% is from improvement by a better control system and 7% is from the new power take-off system.
- A reduction in the overall installation capacity cost of 5% compared with the state-of-the-art.
- A reduction in operation and maintenance costs of 5%.

The test programme will demonstrate the availability, power production predictability, power production capability and medium-to long-term electricity generation costs at € 0.052/kWh in a wave climate of 24kW/m, which can be found relatively close to the coast in the major part of the EC Atlantic coast. In a 36kW/m wave climate, the corresponding cost of energy will be € 0.04/kWh

Wave Dragon marks a significant breakthrough towards commercial exploitation of the abundant energy concentrated in ocean waves. Seagoing trials of the Wave Dragon prototype have proven its offshore survivability since March 2003 and more than verified the potential for commercial feasibility of large-scale power generation below the costs of offshore wind power. Wave Dragon is unique among wave energy converters as it harnesses the energy of waves directly via water turbines in a one-step conversion system and not via moving bodies or air chambers. It is housed in a very simple construction in which, importantly, the turbines are the only moving parts.

Full-scale Demonstration of Robust and High-efficiency Wave Energy Converter

OBJECTIVES

The main objective of the present project is to operate at full-scale one module of the SSG converter, including turbine, generator and control system, in 19kW/m wave climate. The full-scale technical prototype of the SSG includes three reservoirs for capturing the ocean energy and is constructed as a robust shoreline device.

The patented multi-reservoir concept ensures that a variety of waves are utilised for energy production, resulting in a high degree of efficiency. The Kvitsoy municipality has 520 inhabitants and is one of 10,000 islands in Europe where wave energy can quickly be developed into a cost-effective energy production alternative to existing diesel generators. The pilot project features a 10m-wide civil structure module of the SSG which will be completed in 2006.

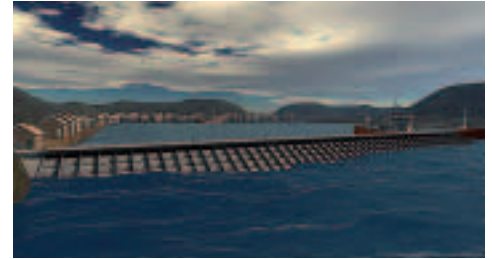
Challenges

The main challenge is the development of the innovative and patented multi-stage turbine in order to obtain a high efficiency with the lower-stage 1,5 meter head and to design a seal with low leakage rate and minimum friction. There is also a certain project risk involved in the design and production of prototype components for the multi-stage turbine: these components often need to be changed subsequent to the first series of tests. Therefore workshop testing is planned and a contingency is also allowed for any re-design, re-production and re-testing that may be necessary before the final prototype components are installed in the pilot plant.

Project structure

In order to carry out the project in a structured manner the following ten work packages are identified:

- WP 1 Development of surveillance, control and data acquisition system: this WP will be headed by AAU, which has substantial experience in measuring performance data from the Wave Dragon project.
- WP 2 Design, manufacturing and testing of the turbine: this WP is considered a technical development activity and will be headed by TUM, which has substantial experience in design, testing and verification of turbines.
- WP 3 Design of generator equipment and SW development: the generator equipment and SW development will need to be tailor-made for the project. Design and SW development work will be technical development activities. GANZ will head the WP and be assisted by IKM with regard to local conditions.
- WP 4 Production and testing of generator equipment.
- WP 5 Installation and commissioning: NTNU will be in charge of the WP and will be assisted by IKM for local installation of the turbine and generator equipment, and ultimate grid connection.
- WP 6 Long-term testing: WEAS will be in charge of the day-to-day follow-up and supervision of the pilot plant.
- WP 7 Performance evaluation: AAU will head this activity based on its detailed experience from performance evaluation and follow-up of the Danish Wave Dragon prototype.
- WP 8 Innovation-related activities.
- WP 9 Assessment of progress and project results: during the work with the individual WPs, progress reports will be submitted every three months. The proposed steering committee will assess the progress and results every six months and, after 12 months, a design review with decision milestone will be held.
- WP 10 Consortium management.



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32 months

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Norwegian University of Science and Technology - NO
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Anna Gigantino

Status
ongoing

Expected results

The expected results of the project are to complete design of the multi-stage turbine, generator and the control system; prepare operation procedure for the SSG wave energy converter including emergency procedure, data handling and data processing; perform workshop testing of the multi-stage turbine/generator and control system; and install the equipment in the SSG pilot plant. After the equipment has been installed and tested, the SSG plant will be connected to the local grid.

Detailed expected results of the project are:

- Design of a full-scale 150 kW technical prototype of the innovative MST turbine technology (by month 12, subject to design review and a decision milestone).
- Manufacture, testing and installation of a full-scale 150 kW technical prototype of the innovative MST turbine technology in the SSG structure (by month 22).
- Design of a full-scale 150 kW generator and control system (by month 12, subject to design review and a decision milestone).
- Measurement of performance data for the SSG wave energy converter, including the structure, in a period of up to six months for reliability and life time assessment (by end of project).
- Manufacture, testing and installation of a full-scale generator and control system for grid connection and annual production of 200,000 kWh of renewable and pollution-free electricity, corresponding to 20,000 kWh/m (by end of project).
- Achievement of hydraulic efficiency of at least 39% for the shoreline application (by end of project).
- A wave-to-wire efficiency of more than 25% during the test period (by end of project).
- 96% availability of plant (with regard to operational hours).
- 85% availability of production (with regard to wave climate).

The success of the project will be measured against these last five specific objectives at the end of the project.

