Proposals for a European Strategy of Research, Development and Demonstration (RD&D) for Renewable Energy from Small Hydropower

Summary

Prepared by the Thematic Network on Small Hydropower (TN SHP)

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This summary of the document entitled Proposals for a European Strategy of Research, Development and Demonstration (RD&D) for Renewable Energy from Small Hydropower is meant to focus on some essential points of the needs in RD&D[1] in small hydropower, and especially on the economic, environmental and social gains of a development of the European strategy.

[1] RD&D : Research, Development & Demonstration

1 FOREWORD

Prioritising Small Hydro Research

The Research, Development and Demonstration (RD&D) Strategy document presents the priorities for Small Hydropower short-term research. In other words, it seeks to explode the myth that there is no longer a need for funding for SHP research.

Indeed, in Europe, whereas the potential for large hydro development is practically exhausted, small hydro has still a huge and untapped potential – abandoned or outdated sites with low head, water networks, … - which will allow EU small-hydro industry to increase its activities.

Contrary to the generally accepted idea that small hydropower is an old energy that has reached such an experience that it cannot be improved; small hydro has still a scope to evolve, especially in equipment and design practises. Therefore small hydro will gain to carry on being improved through RD&D so as to be even more economically, technically and environmentally efficient.

On top of that, without supports, RD&D cannot be undertaken by independent SMEs in small hydro due to the lack of financial and human resources.

Developed by the Thematic Network on Small Hydropower (TNSHP) through the FP5 funded Project (Framework Programme n°5), this RD&D Strategy document represents the combined thinking and close collaboration of manufacturing industry, financiers, research institutions, national energy authorities and EU institutions.

It details the key priorities in terms of electromechanical equipment, control and monitoring systems, environmental integration, civil works, and administrative and marketing issues. This summary of the main strategy document recalls the agenda for the whole priorities divided in technical and non-technical ones.

Although research projects involving small hydropower have been included in successive EU Research & Technological Development (RTD) framework programmes (FP), the number of small hydro power projects funded by these programmes has decreased to the point at which no RTD programme has been developed for SHP under the FP6.

Annually, the proposed overall budget of FP7 represents an increase of nearly 200% on FP6. The portion of this dedicated to energy however, at € 2'931 million, is only some 4% of the total budget, representing a slump in the already increasingly diminishing proportion of framework programme funding assigned to energy (at 66% in 1983). In real terms, the FP7 budget for energy represents an increase of only 3.3 % over FP6.

Finally, there is an urgent need for amendment of the Framework Programme structure to include a specific budget for renewable energy RD&D, including a chapter for small Hydropower, to replace the existing "Sustainable Energy" budget line, which includes technologies not defined as renewable in the EU Directives, e.g. carbon sequestration and hydrogen.

2 OVERVIEW OF THE EUROPEAN SMALL HYDROPOWER SECTOR

2.1 SMALL HYDROPOWER (SHP) DEFINITION

Small hydropower, here defined by ESHA, the European Small Hydropower Association as hydropower below 10 MW, has to be distinguished from large one for economic and technical reasons. Indeed SHP plants cannot be considered as a geometrical reduction of large ones, as their size, turbined discharges, implied budget are quite smaller and as they notably imply specific designs.

2.2 POTENTIALS

Almost in most of the European countries, SHP is a dominant renewable energy source. The total remaining potentials for EU-25, the candidate countries and Switzerland are estimated to some 49 TWh/year, whereas the current SHP electricity generation amounts to 46.5 TWh/year. What can be emphasized is that the remaining potentials consist mainly in low-head sites (below 30 meters).

Moreover, with a turnover between 150 and 180 M€, the European SHP sector employs nowadays circa 10'000 persons in EU-15. But this number could reach 15'000 in 2010 if the European Union target of doubling the share of Renewable Energy Sources (RES) in the EU energy sector from 6 to 12 % by 2010 is achieved.

2.3 OBSTACLES

In spite of its interesting position within the energy sector, SHP has not developed itself as much as the other RES. Indeed SHP development is slowed down by numerous institutional barriers and by the wrong idea that it is a mature technology and that SHP plants injure water streams regarding ecology and leisure interests. Furthermore current economic tendencies give no significant credit to the long useful life and low running cost of SHP plants, and the liberalisation of the European electricity market tends to be negative for small producers, unless they can benefit from special measures such as green electricity prices.

2.4 MAIN CHALLENGE TO RECONCILE ECONOMY AND ECOLOGY

One of the main SHP challenge is to reconcile economy and ecology, which means that the power plants have to be cost-efficiently integrated to the environment. Environment integration implies notably environment-protection facilities such as fish passes, currently expensive regarding the whole cost of the installation, but also an optimal use of water resources, considering that a relevant discharge cannot be diverted. In other terms, environment integration involves non-technological development such as definition of appropriate minimum residual flows, but also technological development so as to create equipments (water intake, power house, turbines) but also material and construction procedures that are economically and environmentally efficient.

On top of that, it can be underlined that better environment integration will have a positive effect on the institutional barriers mentioned before.

2.5 NEEDS FOR A EUROPEAN STRATEGY

SHP deserves to be more widely and effectively developed and promoted through **a co-ordinated and systematic European RD&D strategy, with a focus on information and know-how exchange**, for the following reasons:

- Contrary to large international companies that have experience in large hydropower, Small & Medium Enterprises (SME) working in the SHP field cannot invest large sums to develop new equipments or improve the existing ones. Indeed laboratory developments notably are far too expensive for small turbines, especially these under 1 MW.
- Nowadays most of the RD&D projects are site-specific and their results are not widely disseminated.
- SHP development requires multidisciplinary RD&D, with a dispersed know-how.
- Some techniques developed for other energy sector could be useful for SHP.

The creation of the present Thematic Network on Small Hydropower was one of the actions proposed by ESHA and some other European partners.

The development of the European strategy in small hydropower (SHP) would result in many **economic, social and environmental gains**. The first aim is to **attract investors** (public or private groups) in the European SHP field for setting new plants and rehabilitating old ones, and especially low-head sites. Such investments will lead to develop:

- a **renewable energy**, thus fulfilling the objectives of the Kyoto Protocol, the White Book and the RES-e Directive[2],
- an **indigenous energy**, reducing Europe energy dependency and improving energy security
- a **clean energy**: operation with no gas emissions, no solid wastes, no wastewater and a positive life cycle assessment regarding energy and environment
- **rational use of energy**, especially when recovering energy from water networks
- SHP plants **integrated to the ecosystem**,
- **local employment, industrial competitiveness and SMEs**.

3 PRIORITIES SUMMARY

The next two tables, taken from the source document, give respectively the list of technical and non-technical priorities classified for each subject regarding the following legend:

1: Essential to reach White Paper objectives by year 2010.

2: Useful to reach White Paper objectives by year 2010.

3: Interesting in the scope of White Paper objectives by year 2010.

[2] RES-E Directive: Renewable Energy Source Electricity Directive

The last column refers to the paragraphs of the source document entitled Proposals for a European Strategy of Research, Development and Demonstration (RD&D) for Renewable Energy generated by Small Hydropower where more details are given.

TECHNICAL PRIORITIES	**RD&D**	**Demonstration**	**Dissemination**	**Paragraph**
General topics				***5.1***
Maps, hydrology and residual flow				5.1.2.2
Definition of correct minimum residual flow and/or appropriate flow conditions	1	1	1	
Improvement of hydrological assessment methods	3	3	3	
General design, civil work & engineering				***5.2***
Development of standardized/systemized hydraulic structures with the purpose to reduce design and construction costs	1	1	1	5.2.2
Head enhancement techniques for very low heads	1	1	1	5.2.2
Reduction of penstocks installation costs	2	2	2	5.2.2.3
Finding new methods for maintenance, repair and overhaul so as to have alternatives to conventional cofferdams	2	2	2	5.2.2.4
Finding alternatives to the use of cofferdams during construction	3	3	3	5.2.2.4
Development of efficient desilters with high-head intakes, of proper water intakes, and of trash racks	3	3	3	5.2.2.5
Electromechanical equipment, control & monitoring				***5.3***
Turbines				**5.3.2.1**
Development of appropriate turbines design suitable to electrical output below 1MW	1	1	1	
Development of low-head and very-low-head turbines	1	1	1	
Development of fish-friendly turbines	1	1	1	
Development of submersible turbo-generators	2	1	1	
Tests of new construction materials	3	3	3	
Electrical equipment				**5.3.2.2**
Adaptation of high pole permanent-magnet excitation (PME) generators to SHP	2	1	2	
Development or adaptation of low-speed generators	2	1	2	
Development of variable-speed operation	2	1	2	
Control & monitoring				**5.3.2.3**
Development of standardised hardware packages	2	2	2	
Development of full software support for site-specific digital control, for the control of operational specifications, and for that of generalised control modules and development of a graphical user interface, and of improved monitoring and data analysis	2	2	2	
Environmental issues				***5.4***
Bioengineering techniques applied to a wider range of works	1	1	1	5.4.2.2
Development of appropriate fish screening systems for downstream and upstream migrating fish	2	2	2	5.4.2.4
Standard and objective methods for environmental impact assessment of SHPs	2	2	2	5.4.2.6

NON-TECHNICAL PRIORITIES	**Demonstration**	**Dissemination**	**Political**	**Paragraph**
General topics				***5.1***
Administrative and marketing aspects				**5.1.2.1**
Simplification and harmonisation of administrative procedures	-	-	1	
Setting of binding mandatory national targets for 2010 to generate more efforts in all Member States toward RES-e in General and SHP in particular	-	-	1	
Introduction of regulatory measures in favour of electricity generation from renewable sources	-	-	1	
Coordination between different EU Directives (i.e Water Framework Directive vs RES-e Directive)	-	-	1	
Maps, hydrology and residual flow				**5.1.2.2**
Definition of correct minimum residual flow and/or appropriate flow conditions	1	1	1	
Know-how and information dissemination				**5.1.2.3**
Promotion of dialogue with all the actors concerned by SHP: public authorities, independent producers, fishermen, developers, industry NGOs	-	1	1	
Awareness campaigns to assist in understanding the technology, and promote better acceptance of small hydro	2	1	-	
Development of good-practice design guidelines for developers and engineers	2	2	-	
Assistance to professional institutions encouraging self-control and standards within the industry	3	3	-	
Multipurpose projects and rehabilitation				**5.1.2.4**
Environment-oriented refurbishment of existing plants	1	1	-	
Awareness campaigns to support the development of multipurpose projects	2	2	-	
Electromechanical equipment, control & monitoring				***5.3***
Support cooperation, and the distribution of know-how, between SHP and other industries	1	1	-	5.3.2.2
Environmental issues				***5.4***
Integrated design considering environmental issues from the very early design stages	1	1	-	5.4.2.1
Improvement of the environmental integration of SHPs by means of non-technical measures;	1	1	1	5.4.2.3
Development of local public awareness to environmental benefits and costs of small hydro.	2	2	1	5.4.2.3

3.1 GENERAL TOPICS

3.1.1 Administrative and marketing aspects

On an administrative point of view, SHP development would gain at harmonising EU directives (Water Framework and RES-e ones) and other national or even regional procedures (authorizations to build a new SHP site, water rights,…). Such harmonisation could be achieved notably by creating a European workgroup, producing specific guidelines for RES projects, introducing training programmes for the personnel responsible for the authorization procedures.

On a marketing point of view, SHP development would gain at benefiting from specific measures notably in front of the liberalization of the electricity markets, by considering external costs, implementing green tariffs and labels, forcing regional and national public and private utilities, by law, to accept up to 10 MW from SHPs.
Moreover such measures should be helped by setting binding national targets for 2010 in the RES-e sector.

3.1.2 Maps, hydrology and residual flow

There is also nowadays a lack of harmonisation between the numerous definitions of the residual discharge and/or appropriate flow regimes (based on hydrologic or statistic values, or on physiographic principles, or on velocity and water depth, or also on multi-objective planning considering ecological parameters) and the many formulas for calculating such discharge, which shows that no correct solution has been found so far. SHP development and image would gain notably at comparing existing methods, and, if necessary, developing new ones, that are mainly applicable for specific types of rivers (mountain rivers, low-land rivers, etc.). Such harmonisation of the definitions of correct residual discharge and/or appropriate flow regimes would result notably in reconciling fishermen and environment organisations with SHP plants.

3.1.3 Know-how and information dissemination

SHP sector would gain at disseminating its technical knowledge within the SHP actors, but also more generally among notably fishermen, Non Governmental Organisations, …, so as to promote a better acceptance of this renewable energy. Such information dissemination could be achieved by creating publications, courses, press conferences, installing a small hydro hotline, …
Moreover quality standards and good-practice design guidelines for SHP engineers and developers should be developed so that they could be informed of the technology improvements and could select the best available equipments for building sites or rehabilitating or adapting old ones.
It has to be emphasized that such information dissemination ought to be co-ordinated at European level.

3.1.4 Multipurpose projects and rehabilitation

Multipurpose projects or projects which first objective is not to generate electricity, include notably SHPs set in irrigation, drinking, run-off or waste waters networks.
Campaigns to support the development of multipurpose projects ought to be developed so that market actors, political, private decision makers are informed of the possibilities to make an optimal use of water resources by setting SHPs, to generate electricity, but also to improve flood protection, or to stabilise groundwater level, or to use SHP poundage basin for recreational and fishery leisure, for example.
Moreover SHP would gain at rehabilitating its old sites in front of the remaining potentials by developing environment-orientated renovation techniques and procedures.

3.2 General design, civil work & engineering

Development of SHP plants has to face several problems linked to civil works:

- they represent a major proportion of the total cost, and prevent many small-low head sites to be built or rehabilitated,
- there is a lack of simple and generally applicable procedures and methods of realization,
- each SHP has to be environmentally integrated, which infers special equipments and constraints of construction.

The proposed RD&Ds are meant to:

- gather and synthesize information on best-practice examples of the main hydraulic structures,
- standardize design as far as possible,
- compare this standardized design with real-life practice examples to detect the main reasons of discrepancies and their importance/cost,
- adapt and optimize the standardized design by integrating the above real-life practical experience,
- finding alternatives to the use of cofferdams during construction, repair & maintenance,
- study the possibilities of integration of SHP into existing hydraulic networks (wastewater, clean water) of small communities,
- create guidelines so as to integrate the powerhouse to the environment from the very early design stages and to design the SHP as a whole and not as a sum of a certain number of components

The development of procedures taking into account an integrated design with standardized or systematized civil works and equipments will result in:

- finding the best compromise between techniques, economics and environment,
- helping SHP project developers to foresee the construction phase but also the repair & maintenance phases, making them more efficient,
- making the authorisation award easier to obtain, since the SHP will propose from the beginning of the project measures to reduce the negative impacts on environment.

3.3 Electromechanical equipment

3.3.1 Turbines

The RD&D proposals for a European strategy will result in:

- allowing manufacturers to propose simple, reliable and efficient turbines with guaranteed performances,
- exploiting the important remaining potentials composed mainly of low-head and very-low-head sites,
- covering the high cost of laboratory development, especially for SMEs,
- a better integration of SHP plants to the environment, by using rationally water resources, and by building submersible turbo-generators,

- increasing the cost-effectiveness of the power plant, by simplifying turbine design, while optimising the annual electricity production and by using new materials.

Such RD&D would also allow SME to develop themselves within the SHP market in front of international firms, and to increase their turbines' delivery per year. Such development could also result in employment creation locally.

3.3.2 Electrical equipment, control & monitoring

The electrical equipment of SHP plants including the hardware such as generator, transformer, the control hardware but also auxiliary drives and other peripheral electrical components and the control and monitoring software is a complex field. Except for specialised generator concepts, such as direct coupled permanent magnet generators, the available hardware satisfies the requirements in SHP completely.

However, it is very **difficult and time consuming to achieve the required know-how e.g. in industrial automation in order to integrate components to a working system while simultaneously applying a flexible and manageable control software concept.**

Since the hardware integration and the site specific software development is part of the key know-how of the suppliers of turn-key SHP plants, it is nevertheless essential to be up to date in these fields. This is a very difficult task rather for the SMEs than the larger companies in this field. But not only is the conceptual work challenging.

Furthermore the development of **improved control features in combination with state of the art digital control systems** is a very difficult task that typically requires a high degree of specialisation, which smaller companies can not achieve. Where it comes to new generator concepts and its application to SHP even larger companies cannot build-up on their existing know-how.

This situation is partly due to the relatively small market size of SHP, which in many cases does not justify very specific developments from a purely economic view of the companies involved.

The **extensive use of software tools supporting the electrical engineering work from the conceptual design to the hard- and software testing and final implementation, assembling and commissioning** is most important.

Up to now the use of such software tools is limited to control and automation experts and no SHP specific solutions are available. The main steps would be the introduction of standardised hardware packages, generalised control modules, development of a graphical user interface and the improved of monitoring and data analysis. Ideally all the steps can be performed using one design platform.

In case of specialised generator solutions, the main effect can be expected by compensation of the technical and financial risk of developing and applying concepts to SHP sites through direct R&D and demonstration funds.

The gains that can be expected from a progress in the electrical equipment as described above are basically identical to those of the previous chapter.

An additional economic aspect is the improved reliability and reduced down time for SHP plants.

An additional environmental effect of the use of direct drive generators avoiding gearboxes and auxiliary electrical drives replacing hydraulic systems is the significantly reduced risk of oil hazards and the environmental pollution involved.

3.4 Environmental issues

Regarding hydropower is a renewable energy, improvement of environment protection deals with a better integration of the SHP plants to the local ecosystem. Such better integration deals mainly with noise reduction and reduction of the impacts on fauna and flora and especially fishes. This infers that:

- waterways (pipes, penstock, channels) and their setting and maintenance do not impact on the local ecosystem, by being under ground or/and maintenance-free, …,
- water stream continuity is not broken, by letting an appropriate residual discharge within the stream and by setting efficient fish passes, so that notably fish upstream and downstream migration should not be disturbed.
- fish are not damaged within the turbines: either systems are set to prevent them from entering the turbine, either the turbine has a special fish-friendly design,
- the whole SHP equipment integrates the landscape notably on a visual point of view by using bioengineering techniques for example.

Such improvements could be helped by establishing general guidelines, so as to design from the beginning the power plant as a whole with a focus on environment integration, and find the best environmental, technical and economic solutions. Moreover standard and objective methods for environmental assessment would gain at being developed so that every one concerned by a SHP project (investors, officers, environment associations,…) could base their analysis on an official study.

And finally, techniques and procedures for SHP integration to the environment need to be promoted and disseminated in order to improve local public awareness, to prevent problems that could spoil SHP picture.

SHP integration to the environment is essential when dealing with SHP picture as a renewable energy.

4 SUGGESTED MEANS TO REACH THE OBJECTIVES

The object of this document is to supply the **base** from which the main **RD&D themes are chosen**, and **priorities established**, in the successive RD&D European Commission (EC) programmes.

Activities can be placed in three distinct categories:

1. **RD&D** intended to increase small-hydro environmental integration and competitiveness.
2. **Educational** and **information programmes** to develop sector professionalism, make political and private deciders aware of small-hydro benefits, explain the principal technical elements in the branch, and tend towards a better acceptance of this means of producing renewable electrical energy.
3. **Political activity** in **favour** of **small-hydro**, to simplify authorisation procedures, adopt tariffs which favour the production of clean, renewable energy in the liberalised market (true energy cost-calculation which takes account of ancillary costs), and financially support projects which aim at the rational use of water resources, as in multi-purpose projects, among others.

By acting in those three fields, the EC can play a very important role in the development of small hydro, so as to reach White Paper objectives on renewable energies.

Though hydraulics can seem to be a mature technology, this document demonstrates that the **needs in research**, **development**, and **demonstrations** are still **important**. Systematic catalogue of best practise examples should be established. The EC can support this endeavour both directly, through its own programmes, and indirectly, by coordinating the national programmes of member and associate States, thus avoiding redundancy.

In order to reach that objective, the EC can encourage **cooperation between RD&D public and private institutions**. RD&D expenses in certain fields, like those of electric machines and process-control, are too high to be justified solely by the needs of small-hydro. It is therefore essential to privilege cooperation with programmes having similar needs, like those concerning wind energy, so as to adapt their results to SHPs, at lesser cost.

The **Commission** should thus play a **federative role**, by simplifying information exchange, and avoiding that programmes be partitioned. The market structure of small hydro does not allow its actors to develop new techniques without public support, as the expenses involved are too high. The solution consists therefore in supporting general-interest programmes, and to make the results available to all. **Information-exchange synergies** with the International Energy agency (IEA), which has a workgroup especially for small hydro, should moreover be developed.

The EC should view favourably the creation of a **European association** of **small-hydropower plants manufacturers**, including suppliers of electromechanical equipment, process control, or general enterprise, all of these fields being closely interconnected. The association would favour exchanges, and common RD&D projects, integrated design, and the establishment of sector standards.

In order to handle Education and Information tasks, the EC could rely on existing associations like ESHA, which could, in turn, rely on national or regional associations.

The Thematic Network on Small Hydropower is a first step to help the EC to reach the above mentioned objectives. Small hydro will not give full scope to its potential without EC support.