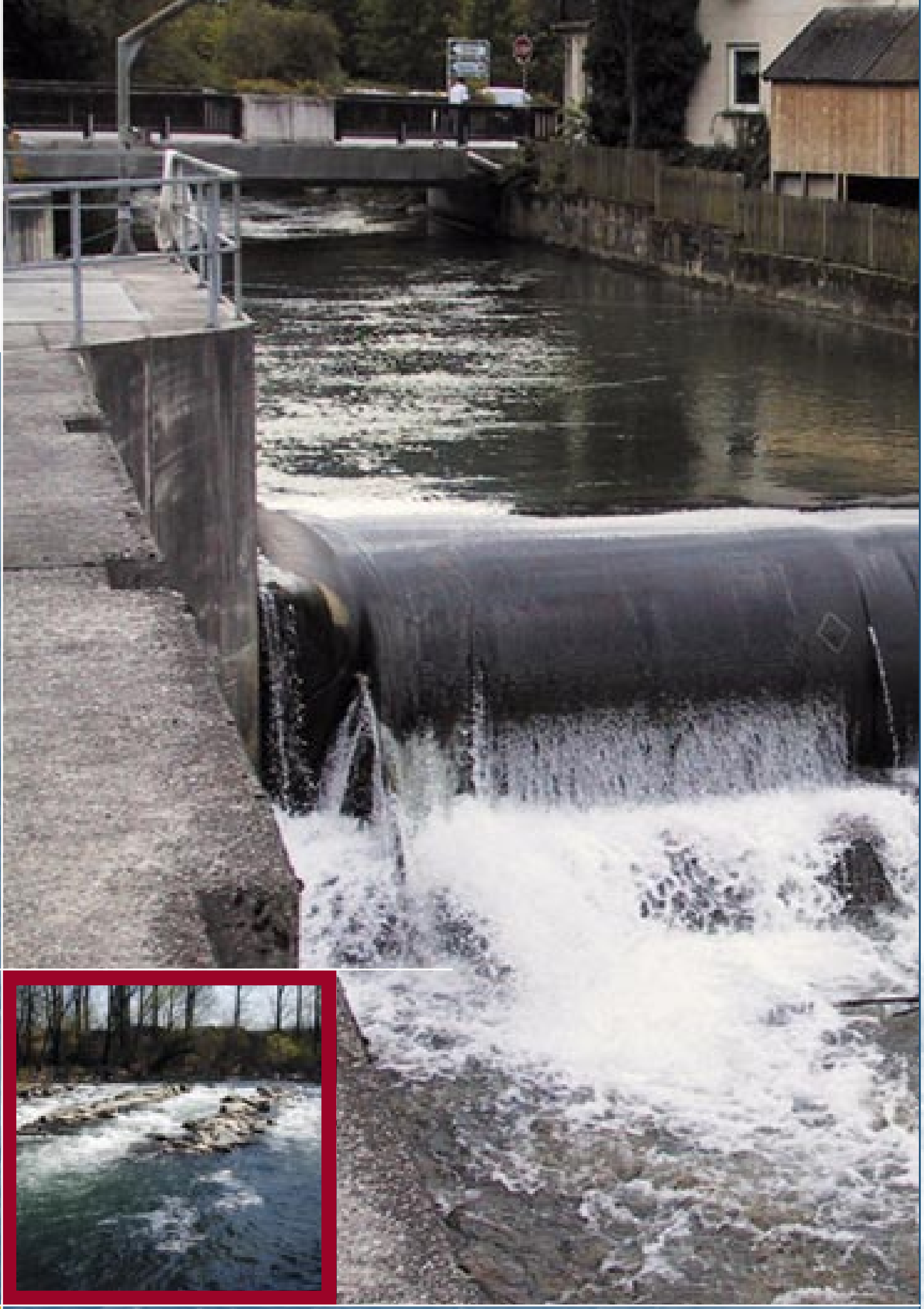
ESHA

European
Small Hydropower
Association



STATE OF THE ART OF SMALL HYDROPOWER IN EU - 25

STATE OF THE ART OF SMALL HYDROPOWER IN EU - 25

with support from

Contents

Small Hydro Power
in Austria
© KÖ

INTRODUCTION

The European and National policy framework for renewables in general and for small hydro in particular has evolved considerably in the last few years: at a European level targets have been set for renewables - **a share of 12% of renewable energy in gross inland energy consumption, and a share of 22% for green electricity by 2010** - and the policy framework has been shaped following the objectives of climate change mitigation and ensuring the fulfilment of European commitments to the Kyoto protocol, ensuring sustainable security of energy supply by reducing dependence on energy imports and the improvement of industrial competitiveness and having a positive impact on regional development and employment. For of all these reasons the promotion of electricity from renewable sources of energy is a high Community priority.

The European policy framework for renewable energies gives Member States a reason to consider Small Hydropower (SHP) because it is the most mature and proven of all renewable energy technologies, with a long historical track-record. At the same time it puts great emphasis on environmental integration.

Looking to the future there are good reasons to support small hydropower:

- Small hydropower is needed to achieve European targets on renewable energies.
- The depletion of oil and natural gas deposits will lead to higher generation costs for thermal plants; by offsetting thermal generation, small hydropower is a leading technology in efforts to reduce greenhouse gases and in climate change mitigation.
- The growth of the world's population, especially in developing countries, will require the appropriate infrastructure for irrigation and water supply; the addition of a hydropower component to such a project is economic and has no major environmental or social impacts but a broad range of benefits as it ensures decentralised energy supply.
- Small hydropower is a much more concentrated energy resource than other renewables, it is predicatable, non-varying and has a higher capacity factor and longlife.

The knock-on benefits of achieving this goal would include:

- Significant reduction of CO_2 emissions;
- Scientific and industrial development in a high technology sector;
- Employment creation;
- Avoided fuel costs;
- Increased security of supply;
- Local and regional development and exports to third countries, which can benefit considerably from European technology.
- Reinforcement of policies affecting the penetration of renewable energies, including: agriculture and rural policy, regional policy, internal market measures in the regulatory and fiscal areas;
- Strengthening of cooperation between Member States, as well as coordinated support measures to facilitate investment and enhance the dissemination of information on renewable energy sources (RES).

However, there is a common perception that SHP is a fully developed technology and therefore, it does not need any significant level of institutional support. It is assumed that market forces alone will be sufficient to take it forward. However, in reality, there is still potential for development and improvement of small hydropower, as the main challenge with SHP is related to both economics and ecology.

On 1 May 2004, eight Eastern European and two Mediterranean countries: the Czech Republic, Cyprus, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia, (EU-10) joined the EU. Bulgaria, Romania and Turkey (Candidate countries- CC) are expecting to join the EU in the near future. The picture of European Small Hydropower has changed. The enlargement of Europe gives a great opportunity to transfer experiences on SHP development to the New European Members States. Indeed, Small hydropower has a huge potential in these countries, where it is the dominant renewable energy source. Its further promotion is required to achieve EU targets for renewables and EU commitment to the Kyoto protocol.

Naturelike bypass channel, Austria
© BOKU

Exploiting the Water Resource

Approximately 70% of the earth's surface is covered with water, a resource that has been exploited for many centuries. Hydropower throughout the world provides 17% of our electricity from an installed capacity of some 720GW, making hydropower by far the most important renewable energy source for electrical power production. The contribution of Small Hydropower (SHP) to the worldwide electrical capacity is of a similar scale to the other renewable energy sources (1-2% of total capacity), amounting to about 61GW. Europe with about 13GW installed capacity has the second biggest contribution to the world's installed capacity, just behind Asia. Indeed, hydropower now accounts for around 84% of electricity generated from renewable energy sources in the EU-15, and 19% of total electricity production in Europe. Electricity generation from SHP contributed about 2% to the total electricity generation in the EU-15. About 9% of the RES electricity generation and 4% of the RES primary energy in the EU-15 were produced by SHP plants in 2002.

Small Hydropower schemes, considered as those with installed capacity of up to 10 MW (generally accepted limit for SHP and adopted by ESHA and the European Commission), generate electricity or mechanical power by converting the power available in flowing water of rivers, canals and streams. SHP schemes are mainly run-of-river with little or no reservoir impoundment. The objective of a hydropower scheme is to convert the potential energy of a mass of water, flowing in a stream with a certain fall (termed the "head"), into electric energy at the lower end of the scheme, where the powerhouse is located. The power of the scheme is proportional to the flow and to the head.

The principal requirements for electricity generation from water are:

- Suitable rainfall catchment area,
- Hydraulic head,
- Means of transporting water from the intake to the turbine, such as a pipe or millrace,
- Turbine house containing the power generation equipment and gate valve,
- Tailrace to return the water to its natural course
- Mechanical or electrical connection to the load to be supplied.

SHP has a key role to play in the development of Europe's renewable energy resources, and an even greater role in developing countries. In the face of increasing electricity demand, international agreements to reduce greenhouse gases, environmental degradation from fossil fuel extraction and use, and the fact that, in many European countries, large hydro power sites have been mostly exploited, there is an increasing interest in developing SHP. Indeed, SHP has a huge, as yet largely untapped potential, which will enable it to make a significant contribution to future energy needs, offering a very good alternative to conventional sources of electricity, not only in Europe but also in developing countries.

ADVANTAGES OF SMALL HYDROPOWER

A clean and renewable energy source.

Small Hydropower is :

- Efficient resource
- Secure resource
- Clean resource
- Renewable resource
- Sustainable resource

- Hydropower **does not produce greenhouse gas emissions,** which are the major cause of the international concerns about environmental problems: Hydroelectricity does not involve a process of combustion, therefore it avoids polluting emissions like carbon dioxide (responsible for global warming) that otherwise would be produced by conventional energy when burning fossil fuels. SHP, like any energy-production activity, has impacts on the local ecosystem (on the quality of river and river ecosystems, noise, landscape). However, new legislative frameworks, innovative technology, improved methods of operating SHP and above all the willingness of all actors to integrate environmental concerns are steadily reducing these local environmental impacts. These techniques are technically and economically viable as well as socially acceptable, offering a good compromise with other river users.
- SHP **contributes to sustainable development** by being economically feasible, respecting the environment (avoiding greenhouse gas emissions) and allowing decentralised production for the development of dispersed populations.
- SHP is a **clean energy** source (it does not produce waste in the rivers, or air pollution) and **renewable** (the fuel for hydropower is water, which is not consumed in the electricity generation process)

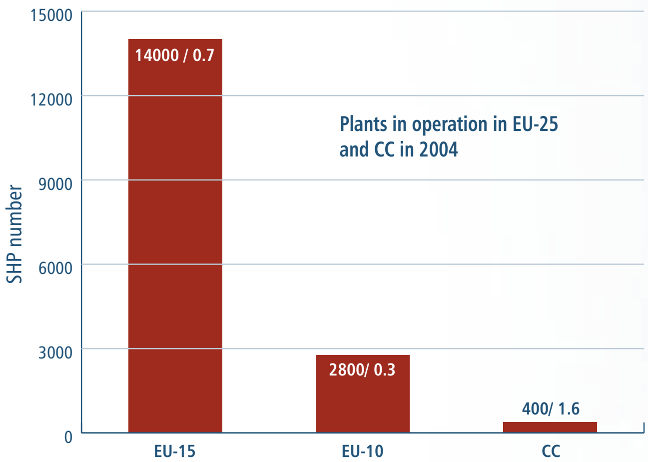
- SHP plants, if well equipped, with fish ladders and environmentally friendly runner blades, **are not an obstacle for fish migration.**
- Small hydropower plants ensure a minimum flow downstream, **ecological or reserved flow** that **guarantees fish life.**
- **Grid stability:** Building SHP plants helps create a more **diversified electricity system,** providing production of electricity in smaller distribution systems when the main grid is disrupted. Furthermore, since SHP is a decentralised energy source located close to the consumers, **transmission losses can be reduced.**
- SHP **mobilises financial resources** and contributes to the economic development of small dispersed populations, ensuring autonomous and reliable energy for the long term.
- SHP plants create **local jobs** for the monitoring of the operation of the plant.
- SHP schemes assist in the **maintenance of river basins** by allowing the recovery of floating waste from the rivers, the monitoring of hydrological indicators and the refurbishment of old SHP plants.
- **High energy payback ratio of SHP,** for each power generation system, the "energy payback" is the ratio of energy produced during its normal life span, divided by the energy required to build, maintain and fuel the generation equipment. If a system has a low payback ratio, it means that much energy is required to maintain it and this energy is likely to produce major environmental impacts. Hydropower run-of-river -30 to 267; Biomass- 3-27; Windpower- 5-39; Solar photovoltaic - 1-14. The payback ratios do not vary much for fossil energies, but vary significantly for renewable energies. This is due to variable site conditions (topography for hydro, quality of the wind, intensity of solar radiation of solar energy).

Status of SHP in EU-25

SHP PLANTS IN OPERATION

In the former EU-15 about 14 000 SHP plants are in operation with an average size of 0.7 MW. There are around 2 800 and 400 SHP plants installed in EU-10 and in the Candidate Countries (CC) respectively. The average plant size of these categories is 0.3MW EU-10 and 1.6 MW in EU-CC.

700 kW is the average installed capacity for a SHP plant in EU-15	**300 kW** is the average installed capacity for a SHP plant in EU-10	**1.6 MW** is the average installed capacity for a SHP plant in EU-CC

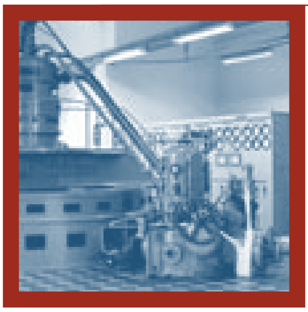


SHP INSTALLED CAPACITY AND ELECTRICITY GENERATION

The total installed capacity of SHP plants in New Member States and CC (1430 MW) is at least 10 times smaller than in the former EU-15 (10828 MW). Electricity generation by SHP plants in the former EU-15 is considerably higher in comparison to the EU-10 and the CC; production is nearly 15 times bigger than in the EU-10 and 30 times bigger than in the CC. SHP production shows the real economic value that SHP sector provides in each group of countries and these figures show the high potential for increasing the electricity generation for power plants in the New Member States and CC by improving their efficiency in their operation and maintenance.

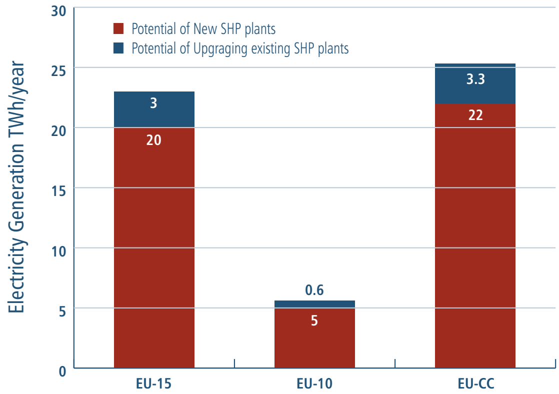
According to Eurostat figures for 2004, Italy accounted for about 21% of the total SHP installed capacity in the EU-25, followed by France (17%) and Spain (16%). In the New Member States, Poland and the Czech Republic both with 2% of the total EU-25 SHP capacity, are the lions of the New EU Member States. From the Accession Countries, Romania and Turkey represent about 25% and 15% respectively of the total SHP installed capacity in 2002 in EU-10 +CC

At present, in almost all countries hydropower is a dominant source of energy in RES-E production. Small hydropower accounts for approximately 4.6 % of total hydro generation in the new EU Member States and CC. None of the other renewable energy sources (wind, biomass, PV etc) is able to compete with small hydropower in these countries.

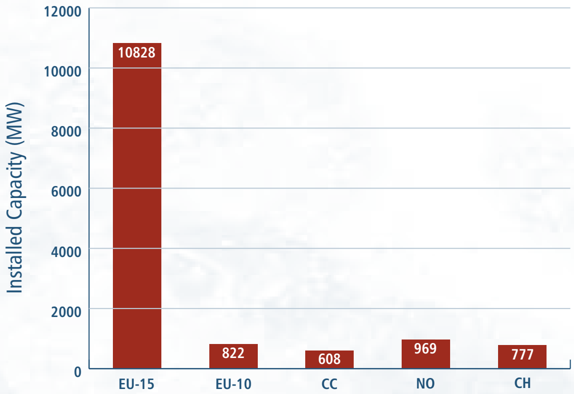


Inside a refurbished SHP plant in Sweden © SERO

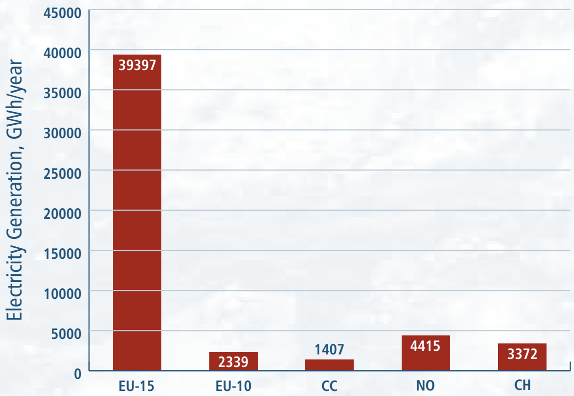
Remaining Small Hydropower Potential in Europe, ESHA 2004



SHP installed capacity (MW) in EU-25, in the Candidate Countries (CC) and for Norway (NO) & Switzerland (CH) in 2004



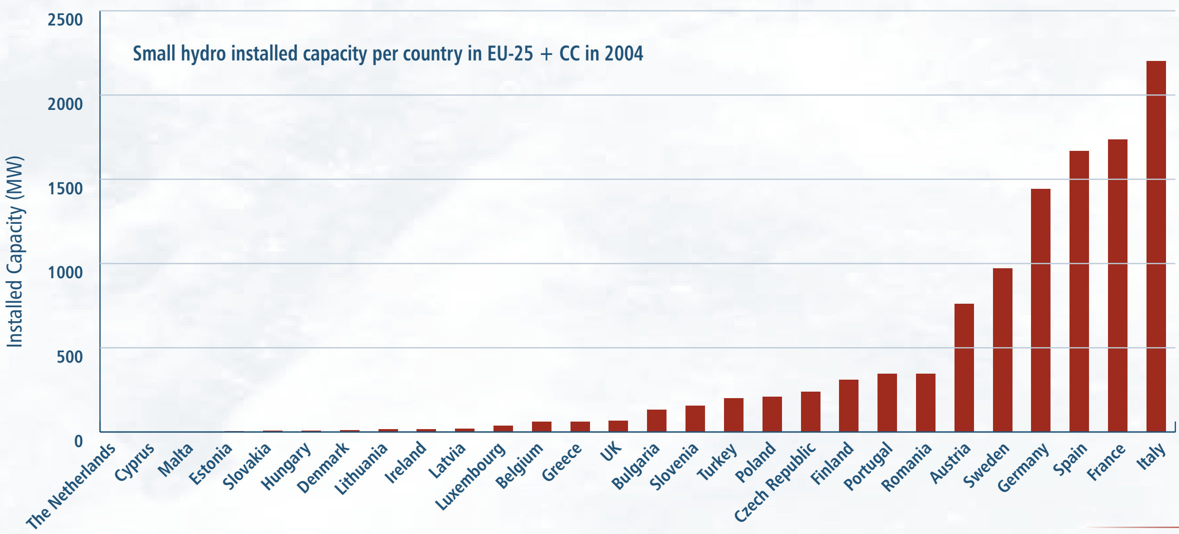
SHP Electricity generation in EU-25, in the Candidate Countries (CC) and for Norway (NO) & Switzerland (CH) in 2004



SHP POTENTIAL

Among the renewables, small hydropower has a key role to play being a long - established technology - but still with room for technological development and with high-untapped potential, especially as a cheap and clean solution in developing countries.

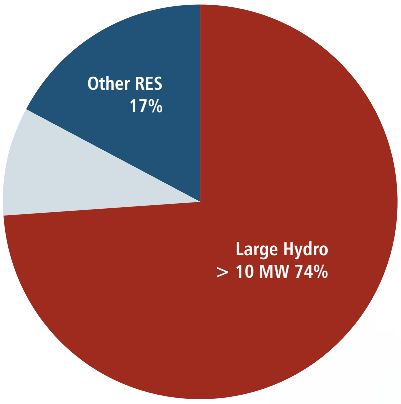
So far, more than 82% of all economically feasible potential has been exploited in the former EU-15. The SHP resource exploitation rate in the EU-10 is less than half of that in the EU-15 and very small in the CC (5.8%). The remaining economically feasible potential amounts to some 23 TWh/year in EU-15, 30.9 TWh/year in the New Member States and CC (5.6 TWh/year in EU-10). The majority of this potential (roughly 80% or 19 300 GWh/year) is located in Turkey. Poland and Romania rank second, having indicated potential 6 to 10 times lower than that of Turkey. The third group is composed by the Czech Republic, Slovenia, Bulgaria and Slovakia. The largest proportion of the potential in Europe involves low-head plants and the refurbishing of existing sites.



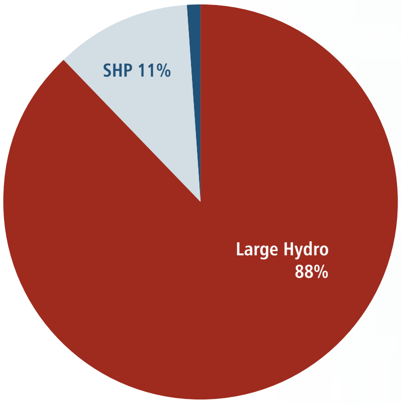
SHP IN THE RENEWABLE ENERGY MIX

Hydropower is the largest Renewable Energy Source (RES) in terms of electricity generation accounting for about 84% of the RES electricity generation in 2002. Nevertheless, SHP only represented 9% of the RES electricity generation in the EU-15 in 2002. However, in almost all New Member States and Candidate Countries hydropower is the dominant source of energy in RES-E production. The RES-E share in EU-10 is hydro 98.7% (large 87.5%, small 11.2%), other RES (1.3%).

RES-E Generation Share in EU-15, 2002



RES-E Share in EU-10 in 2002



Small Hydro Power in France © Ademe

SHP ECONOMICS AND COSTS

In general large hydroelectric plants have little difficulty in competing in the market place with conventional generation, whereas small hydro, especially the very small and the low head plants, can normally only compete where allowance is made for the external costs associated with fossil fuels and nuclear power.

The capital required for small hydro plant depends on the effective head, flow rate, geological and geographical features, the equipment (turbines, generators etc.) and civil engineering works, and whether water flow is constant throughout the year. Making use of existing weirs, dams, storage reservoirs and ponds can significantly reduce both environmental impact and costs. Sites with low heads and high flows require a greater capital outlay as larger civil engineering works and turbine machinery will be needed to handle the larger flow of water. If, however, the system can have a dual purpose - power generation as well as flood control, power generation and irrigation, power generation and drinking water purposes- the payback period can be shortened.

Nevertheless, these are not the only factors to look at when deciding to invest and run a SHP plant. Special attention has to be paid to the cost of using water (water charges and/or concession fees) as well as to the administrative procedure to obtain the water and building licenses.

Apart from the investment and production costs, another principal cost element is operation and maintenance (O&M), including repairs and insurance. This can represent from 1.5-5% of investment costs. Both the production and investment costs differ considerably depending on the head of the plant. Clearly, the cost per installed kW is not the only interesting parameter since it alone cannot determine whether the plant is profitable. The average cost per kWh produced, as a function of head and power, would also have to be taken into account.

Investment and production costs of SHP plants in some Member States of the EU (2003)			
Country	Average SHP production costs (€cents/kWh)	Range Investment Costs €/kW	Average O&M costs (€cents/kWh)
Spain	3.5 - 7	1500	0.9
Austria	3.6 - 14.5	2500	0.4
Sweden	4 - 5	1800 - 2200	1.4
Czech Republic	2 - 3	660 - 2000	-
Lithuania	2.5 - 3	2200 - 2500	-
Poland	3	500 - 1200	-

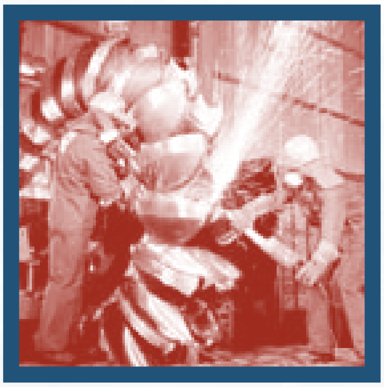
Current and future development costs

Power production costs for SHP-generated electricity will not fluctuate much in the future as it is a mature technology. Further development will therefore focus on installation costs. The specific capital cost of small hydropower installed capacity depends on the size of project; the cost per installed kW is highest where water heads are lowest but it decreases rapidly as head increases. At about 15 m, the rate of decrease levels out and, eventually, the cost stabilises. **Two potential areas of improvement exist therefore, the first concerning cost reductions for heads smaller than 15 metres, the second for developments supplying less than 250 kW.** As a large proportion of the potential in Europe involves low-head plants, the benefits of concentrating development efforts in this area, and particularly for low power developments, are obvious.

SHP INDUSTRY STATUS

The EU has a multi-disciplinary and highly skilled small hydro industry, which offers the full range of products and services required to develop small hydro projects from initial feasibility and design through to manufacturing, financing and operation. The EU SHP industry generates an annually turnover of around 150 - 180 M€. and it has maintained a leading position in the field of hydropower manufacturing since the technology started to develop 150 years ago. Very little non-European equipment has been installed in European hydropower plants. One important reason for European dominance has been the strong home market. By developing technology and production methods in a fast-growing home market, European manufacturers have, with few exceptions, kept a leading edge compared to manufacturers from other parts of the world.

Several hydro manufacturers are active in small hydro in the European Union. Four major multinational companies dominate the market for larger turbines, but the market between 0.5-5 MW/site is more open to smaller companies. European companies have pioneered much of the technical development, and in recent years have dominated international contracts for small hydropower equipment and installations. In the EU New Member States, the Czech Republic and Slovenia are the main countries with highest levels of turbine manufacturing industry.



SHP Industry
© VAtech

SHP EMPLOYMENT

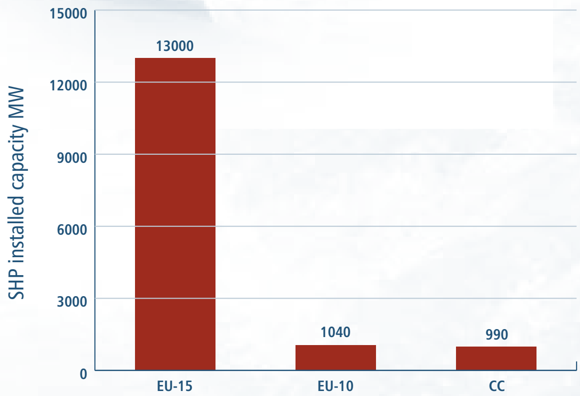
The EU SHP industry is multi-disciplinary and highly skilled, employing about 20,000 people and offering a full range of products and services for the sector. Following the projections from EREC (European Renewable Energy Council) developed for 2020, the number can reach 28,000 for direct and indirect jobs.

Setting up of a Turbine in Switzerland (c) MHyLab

SHP PROJECTIONS INTO THE FUTURE

Small hydropower installation will continue to grow in Europe. Installed capacity and corresponding generation is expected to increase from 11% to 30% by the year 2010 and 2015 in the former EU. About the same rate of increase will be kept for EU-10 (11-49%). The Candidate Countries are expected to achieve a more significant growth of the SHP sector (34-72%).

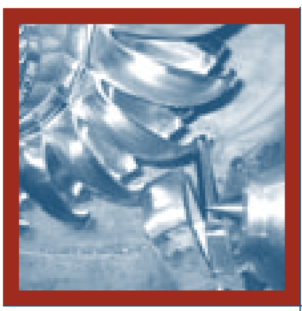
Projection of installed capacity for 2015



SHP R&D

EU-funded research and development programmes have made considerable inputs to the small hydropower industry over recent years. The results of such programmes include the development of environmentally friendly turbines, fish ladders, trash rack cleaning machines and low noise gearboxes. A principal objective of future R&D is to promote further small hydropower market penetration by financing research into:

- Further cost reductions, especially in very low head schemes
- Minimizing environmental impacts
- Increasing efficiency and reliability
- Tidal and wave energy use
- Sewage waters use



High Efficient Small Hydro Power turbine © MHyLab

Contrary to the generally accepted idea that hydropower is an old technology that has reached such a level of development that it cannot be improved, small hydro has still scope to evolve, especially in equipment and design practises. Indeed, RD&D is essential in this field in order to develop efficient, economical and environmentally friendly equipment and construction methods.

Key areas for future research projects include:

- Policy and market issues
- Environmental and social impacts (development of specific bio-engineering techniques in the field of SHP, awareness campaigns to assist in understanding the technology, and promote better acceptance of small hydro)
- Turbine and design issues (improvement of hydrological assessment methods, development of standardized/systemized hydraulic structures, new construction material, flexible turbines for low heads)
- Grid integration.

SHP IN FIGURES

EU-15
☐ **33%:** the renewable energy industry EU- 15 target for the contribution of renewable energy to electricity production by 2020.
☐ **22.1%:** the renewable electricity target set up by European Directive RES-E by 2010.
☐ **14 GW:** the amount of energy that SHP should need to meet this target, this would generate 55 TWh of electricity per year.
☐ **19 600 GWh/year:** the potential of new plants in EU-15.
☐ **5-15 Eurocents/kWh:** average SHP electricity Production costs.
☐ **€ 1 200-3 500/ kW:** average SHP investment costs.
☐ **14 488:** SHP plants.
☐ **10.8 GW** installed capacity of the 14 488 plants, equivalent to roughly 1.77% of the total EU capacity.
☐ **8.6%** contribution of Small Hydro to total Hydro capacity, producing 40 300 GWh. This means that SHP contributes 2% to total electricity generation.
☐ **700 kW:** is the average installed capacity for a SHP plant.
☐ **20 000:** SHP jobs (direct and indirect) in 2004.
EU-10
☐ **2 770** SHP plants in EU-10.
☐ **820 MW** installed capacity from the 2770 plants, producing 2300 GWh of electricity/year. This would contribute to 0.6% of total electricity generation and 12.8% of the total hydro power in EU-10.
☐ **2.4-3.2 Eurocents/kWh:** average SHP electricity production costs.
☐ **1 200 -2 200/ kW:** average SHP investment costs.
☐ **300 kW:** the average installed capacity for a SHP plant.
☐ **4000 GWh/year**: the potential of new plants in EU-10
CO_2 reduction via small hydropower
☐ 1 GWh supplies electricity to about 220 European households, avoiding the emission of 480 tonnes of CO_2.
☐ Average output of a 1MW small hydropower plant in Austria is 5 GWh/year, provinding electricity to 1100 households.
☐ 5 GWh/year supplies 2200 households in a developing country.

Policy framework

In 1997 the European Commission's White Paper on renewable energy sources COM (97) 599 set the goal of doubling the share of renewable energy sources in the EU energy sector from 6 to 12 % by 2010 which would represent 22.1% of electricity. Projections for each renewable energy technology were made. For SHP this means the ambitious target of reaching 14 GW of installed capacity by 2010, providing 55 TWh of electricity generation, and an increase in the contribution to gross inland consumption from a current 0.2% to 0.3%.

White Paper Small hydropower scenario for 2010- EU15	
Feature	2010 Scenario
Installed capacity	+ 4,500 MW
Electricity generation	55 TWh
Gross energy consumption	4.75 Mtoe

The RES-E Directive gives Member States a reason to look at SHP because it is the best proven of all renewable energy technologies. Of special interest for Europe, from both the economic and the environmental point of view, is exploiting the high potential for upgrading and refurbishment of existing plants.

RES-E DIRECTIVE

Promotion of the RES electricity in the Internal Market Directive 2001/77/EC

Proposed measures

- Quantified national targets for consumption of electricity from renewable sources of energy
- National support schemes plus, if necessary, a harmonised support system
- Simplification of national administrative procedures for authorisation
- Guaranteed access to transmission and distribution for electricity from renewable energy sources

TARGETS FOR SHP

The European Directive for the Promotion of the RES electricity in the Internal Market Directive 2001/77/EC follows up the White Paper on renewable sources of energy. It also constitutes an essential part of the package of measures needed to comply with the commitments made by the EU under the 1997 Kyoto Protocol on the reduction of greenhouse gas emissions.

According to the RES-E Directive the renewable energy sources should provide 22% of electricity in the EU-15 by 2010. But on the 1st of May 2004, 10 Countries joined the EU. Therefore, national indicative targets have been also set for New Member States for the contribution of electricity produced from renewable energy sources to gross electricity consumption by 2010.

TARGETS	RES-e %, 1999	RES-e %, 2010
EU -15	13.9	22
EU-10	5.4	11.1
EU - 25	12.9	21

Within this legislative framework, there are three aspects which concern the small hydropower sector in particular: (i) targets set in the legislation and the difficulty in achieving them, (ii) tariff structures and support schemes currently in force and their effectiveness and (iii) administrative barriers still standing despite the new favourable legislative framework.

SUPPORT SYSTEMS

So far experience clearly shows than only feed-in systems and fixed-premium mechanisms have proven their ability to be effective in attracting investments, creating investors confidence, reaching the national targets and creating a technological diversity (ie in Spain, Germany, Austria).

MARKET INCENTIVES AND SUPPORT MECHANISMS

The promotion of renewables, aimed at increasing their share in the fuel mix, notably by ensuring efficient and appropriate support schemes is at the core of the EU energy policy objectives:

- Security and diversity of supply,
- Competitiveness and
- Environmental protection.

The biggest disadvantage of RES at the moment is that under the current framework conditions, characterised by the non-internalisation of external costs of energy production, costs tend to be significantly higher than those of conventional sources of energy. It is generally acknowledged that conventional energy sources not only do not pay their full external costs, but on top of that are strongly subsidised. The result is that electricity generated with renewable energy sources cannot compete on a free market with conventional generation. Hence, some form of market incentive or support is required to develop the technology. Consequently, in order to develop positively, renewable generated electricity requires two essential elements: (i) a stable regulatory environment to attract investors and (ii) a price support mechanism that enables renewables producers to enter the market and make a reasonable profit.

To facilitate and accelerate RES uptake in general and of small hydropower in particular, governments have a range of policy options at their disposal. Supports can target either the production costs or the investments costs. Indeed, as a result of the adoption of the RES-E Directive in 2001, several national support mechanisms have been introduced during the past years and still be in the implementation stage. So far the experience clearly shows in terms of market penetration and growth rates for small hydropower that only feed-in-tariff systems and fix premium mechanism have proven their ability to be effective in attracting investment, creating investors confidence, reaching the national targets and creating technological diversity.

RES support policy mechanisms

	Supply side	Demand side
Generation based (kWh)	Feed-in tariffs Fiscal measures Bidding systems	Quota obligations / Green certificates (Fiscal measures)
Capacity based (kW)	(Subsidies) Investment subsidies (Fiscal measures)	(Quota obligations)

ENVIRONMENTAL DIRECTIVES AND SHP

European Water Framework Directive and Small Hydropower

On 23 October 2000, the "Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy" or for short the EU **Water Framework Directive** (WFD) was finally adopted.

The WFD is an environmental directive, protecting water bodies and focusing on water quality. The implementation of the Water Framework Directive raises a number of shared technical challenges for the Member States, the Commission, the Candidate Countries and other stakeholders. In addition, many of the European river basins are international, crossing administrative and territorial borders and therefore a common understanding and approach is crucial to the successful and effective implementation of the Directive. Small hydropower is not directly mentioned in the WFD. However, depending on the strictness of its interpretation, the SHP sector can be potentially affected by the WFD. Indeed, this rigorous environmental framework provides for the satisfactory integration of SHP with the natural environment. However some inconsistencies on the WFD terminology and its implementation in contradiction with the RES-E Directive may lead to a loss of production of SHP plants. The targets of the RES-E directive can never be reached in matters of SHP if there is no harmonisation between both directives. The solution lies in more precise terminology for the WFD that would make its transposition clear and predictable.

WFD DIRECTIVE

Water Framework Directive

WFD Goals

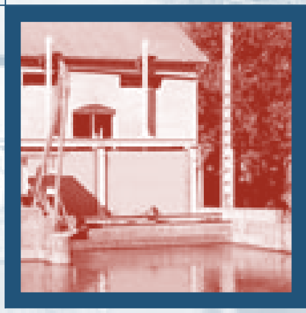
- Protection of all water bodies from further impacts decreasing the features of ecological quality
- Continuous efforts to increase the features of ecological quality

WFD implementation

- Definition of hydromorphological alteration
- Classification of heavily modified water bodies
- Taking into account environmental benefits of electricity from Hydropower.

Small hydro project plants are subject to an environmental impact assessment that identifies their potential impact and proposes feasible solutions

Teledec Plan,
France 680 kW
© GPAE



BARRIERS

Since the RES-E Directive came into force further development of SHP has taken place, particularly, due to the implementation of support schemes, which have established more favourable tariffs for the electricity produced by SHP. However the real barriers SHP has to cope with are:

- Administrative and
- Environmental,

Although SHP has, like all renewables, economic and technical barriers, they are not the most serious problems. In economic terms investing in SHP costs as much money as investing in other renewables but with the advantage that SHP projects have a long life, which, provided there is an adequate tariff structure can give the investor a reasonable return. As regards technical issues, small hydropower is not a new technology. However there is still some room fro R&D activity in Small Hydro. Improvements in technique are focused on new and better materials, more efficient, cheaper and environmental friendly equipment, and better design.

Two barriers to the development of small hydro that instead of reducing with time and legislative support are getting harder: numerous institutional barriers also still stand in its way, mainly resulting from the difficulties inherent in gaining permission to use water from rivers, and also due to perceptions that small hydro plants might adversely affect fishing, despite numerous environmental measures to reduce the local environmental impacts of SHP plants: difficulties in gaining affordable connections to the grid are also common, although this situation is tending to improve. Even though progress so far seems disappointing to many involved in advancing its use, with a new international climate of concern about global environmental dangers, small hydropower clearly deserves to be more strongly promoted and more widely and effectively developed.

Environmental Impacts assessment and SHP

The Environmental Impact Assessment is a procedure to support decisions. The objective is the identification and analysis of the negative and positive effects that a project might have on the environment and health, to assist with decision-making among various possibilities and solutions. Carrying out the environmental impact assessment is the responsibility of the project developers normally via specialised consultants. The control, monitoring and verification of the results are done by the National Bodies responsible for this. **Small hydro project plants are subject to an environmental impact assessment that identifies their potential impact and proposes feasible solutions.** An Environmental Impact Assessment is a repeatable process (according to a standard format) and therefore as transparent as possible: this is a very important requirement, which must be reflected in the clarity of data and in the methods of the approach accepted both by the proponent and the relevant authorities. The agreement of the parties involved in the process on the general methodology forces each party to follow a path made of precise and defined steps avoiding as far as possible arbitrary evaluations.

15% ESTIMATION FOR LOSSES IN HYDROPOWER PRODUCTION IF THE WFD

Small Hydropower respects and protects the environment

SHP AND CLIMATE CHANGE

Energy is a key issue for sustainable development and poverty alleviation. It affects practically all aspects of social and economic development, including living conditions, water, agriculture, population, health, education, and job creation. The European Commission estimates that global energy demand will increase by 70% over a period of 30 years (2000-2030). The strongest growth in demand is projected in developing countries, especially China and India.

The growth in energy demand will cause a considerable increase in greenhouse gas emissions. In the EU, by 2003 CO_2 emissions are projected to increase by 18% in 2030 compared to the 1990 level. Renewables are 'the' solution to climate change: a mainstream set of energy options capable of providing cost-effective and reliable low-carbon energy. By reaching the 2010 target of 12% for the share of total energy consumption produced by renewables, the EU will fulfil 95% of the CO_2 savings necessary to meet the EU Kyoto commitment. Hydropower is the first renewable energy source in terms of global production, and therefore has a key role to play in the development of renewable energies, which will allow it to make a significant contribution to future energy needs, offering a very good alternative to conventional sources of electricity.

Climate Change has been defined as the major international problem faced nowadays by the international community. Climate change mitigation outlined in the various intergovernmental conferences on climate change and the Kyoto protocol, justifies on its own a major development of renewable energies. However, it is not the only argument: renewables contribute to increasing the security of supply by reducing dependence on imported fossil fuels. This import dependency results in economic, societal, ecological and safety policy problems. Energy supply is a vital service of public interest.

Small hydropower contributes to climate change mitigation because:

- **It is an inexhaustible energy source**

Small hydropower cannot be depleted, unlike for example fossil fuels, of which there is a finite supply. Among all renewable energies hydropower is the leading renewable source in the European Union.

- **It does not produce Greenhouse gase emissions**

Hydropower does not involve any combustion, and therefore does not release any oxide in the atmosphere; in particular it does not release carbon dioxide, the principal gas responsible for global warming.

20% BY 2020

20% by 2020 is EREC's Renewable Energy Target for Europe. EREC has been calling for an increase in the overall renewable energy target for the EU to 20 per cent by 2020. This was an agreed outcome of the European Conference for Renewable Energy "Intelligent Policy Options" in January 2004 in Berlin.

- Renewables contribute to increasing the security of supply
- Renewables have the lowest Environmental Impact of all energy sources.
- Renewables offer sustainable energy development world -wide.
- Renewables reduce the risk to public health
- Renewables reduce the costs of the supply chain of centralised conventional energy production

	Petroleum (tons)	Coal (tons)	Natural gas (tons)	Hydropower
Carbon dioxide	3000	3750	2250	-
Oxide of nitrogen	3,7	0,6	2,2	-
Sulphur dioxide	4,5	4,5	0,02	-

Comparative emissions from a small hydropower plant of 1000 kW, working 4500 hours/year and other sources of electricity production

The production of 1000 MWh

- Supplies electricity for one year to about 250 households
- Avoids the emissions of about 480 tons of CO_2

ENVIRONMENTAL LIFE CYCLE ANALYSIS

On the basis of **Environmental Life-cycle analysis** that looks at the environmental impacts of a project from “cradle to grave”, accounting for construction, electricity production and project removal, run-of- river small hydropower has the lowest emissions per unit of energy, followed by wind energy.

SHP AND RIVERS ECOSYSTEMS

Water from a river has different uses; potable water, water for agriculture, water for industry activities, fishing, aquatic sports. SHP is one of those activities and, like any human activity, has some impact on the natural environment. However, new technical developments, the regulatory framework and the willingness of project developers to accommodate environmental concerns with the hydropower production have considerably decreased these environmental impacts. Besides, SHP also has positive global environmental impacts and local social benefits: it replaces fuel based power production and therefore contributes to climate change mitigation by avoiding greenhouse gas emissions and as well as other harmful substances that have considerable effects on human health. Recent innovations in turbine designs have resulted in hydro systems that allow fish to swim through them : so-called fish friendly turbines.

Fish friendly turbine © VAtech

SHP IS :

- An **efficient** resource. It can satisfy energy demand with no depletion of the resource and with little impact on the environment
- A **secure** resource. Hydro is available within the borders of one country and not subject to disruption by international political events. This guarantees its security of supply
- A **clean** resource. It does not involve a process of cobustion, therefore avoiding polluting emissions
- A **renewable** resource. The fuel for hydro-power is water, which is not consumed in the electricity generation process
- A **sustainable** resource. It meets the needs of the present without compromising the ability of future generations to meet their own needs

The quality of the water:

Contrary to large hydropower that works with big dams that store large quantities of water, SHP schemes are mainly run-of-river with little or no reservoir impoundment. Small dams create small ponds, which are very favourable for ecosystems, fish and water storage. Therefore, SHP is not simply a reduced version of a large hydro plant. The correct equipment is necessary to meet the fundamental requirements for environmental integration; simplicity, high energy output, maximum reliability, and easy maintenance. Besides, the production of electricity by SHP does not produce any harmful discharge to the river. The water after passing through the turbine is exactly the same quality and quantity as before. A proof of this is that some SHP schemes dispense potable water downstream. In addition, SHP schemes assist in the maintenance of river basins by allowing the recovery of floating waste from the river, the monitoring of hydrological indicators and the refurbishment of old SHP plants.

The river ecosystem

Environmental impact assessments are required for any small hydropower project. These assessments allow hydro-biological analyses to measure the impacts on the flora and on the fauna in order to avoid irreversible damage and to define environmental impact mitigation measures. The establishment of a minimum reserved flow is also required to maintain the quality of the river ecosystem without any significant alteration due to the small hydro plant.

Among these measures the installation of fish ladders has lead to a considerable increase in environmental performance of small hydro plants. Fish ladders allow fish to bypass a weir safely.

The landscape

By using local materials and local architectural techniques to integrate the power house into the landscape the visual impact of small hydropower plants can be minimised. Noise can be minimised by good design for new small hydropower plants or proper noise abatement measures or underground works in existing plants. At the same time the refurbishing and upgrading of old and abandoned mills can contribute to the protection of cultural heritage.

There are wide ranges of environmental mitigation techniques that are technically and economically viable and most of them are socially acceptable offering a good compromise with other river users. There are good examples cases in the EU where the use of appropriate technologies, measures or methodologies have minimized potential damage to the environment

MULTIPURPOSE SHP

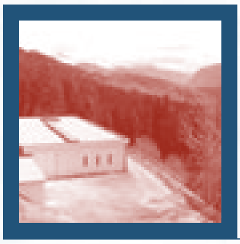
Multipurpose Hydro Schemes

Competition for the use of water has always been strong, but especially in the last few years it has become even stronger. A solution is the multiuse of water resources. This means combining electricity production with other water uses such as irrigation, recreation, and drinking water supply. It means the multiple use of water connected with small hydropower plant realisation. Multipurpose schemes successfully allow compromise between different public interests while reducing the environmental impacts.

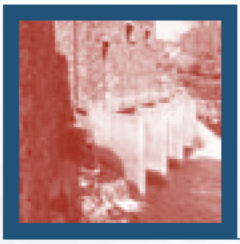
ISO 14001

ISO 14001 - Environmental management systems

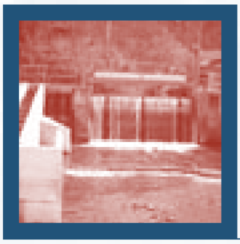
Small hydropower producers are concerned about environmental protection and impact minimisation. For example the association of small hydropower producers in France (GPAE) is continually promoting voluntary environmental certification with ISO 14001 for small hydropower plants in France. The principal objective of this internationally recognised environmental certification system is the continuous improvement of the environmental performance of small hydropower plants.



La Zour drinking water power plant in Switzerland © MHyLab



Powerhouse dressed in local material © IT Power

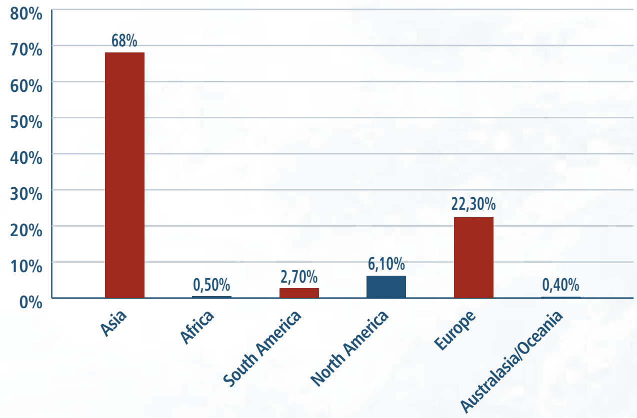


Vertical slot fish-way © Boku

Market opportunities

Two dynamics govern hydropower development around the world. In developing countries, it is economic growth and the increase in energy demand. Asia, especially China and India, is affirming itself as the leading continent for hydropower, with 83,000 MW scheduled to be installed. By contrast, Africa has only 2,000 MW of new installations planned. This brings new opportunities for export and technology transfer which offer good prospects for EU manufacturers. Central and Eastern European countries are also showing increasing interest in further small hydropower development.

World Regions' Contribution to World's SHP Installed Capacity



Target countries with favourable conditions for SHP exports. Source: ESHA, 2003		
Region	**Time frame**	**Countries for consideration**
Latin America	Short to medium term	Brazil, Peru, Argentina, Ecuador, Colombia
Africa	Immediate	Uganda
Central and Eastern Europe	Short to medium term	Slovakia, Poland, Czech Republic, Ukraine; most independent countries in former USSR region
Asia (excluding India and China)	Short to medium term	Nepal, Thailand, Sri Lanka, Philippines, Indonesia, Laos, Vietnam
Other	Immediate	India, China, Russia, Caribbean, Cuba

Challenges

SHP offers one of the most practical and immediately realisable routes to expanding the use of renewable energy sources in Europe, at the same time boosting exports by strengthening the technically advanced European small hydro manufacturing industry. However, the official support for the technology is generally limited and the framework conditions need to be improved. Awareness of the benefits of small hydro and the need to develop a more objective view of its true environmental impact are therefore both essential components in any future strategy to develop its use.

Effective and realistic standards for meeting requirements to minimize any environmental problems are needed, while tariffs for electricity should reflect the technology's low environmental impact and high potential performance.

The initial strategic requirements are for small hydro to feature more prominently in national and EU energy planning, with a view to its stronger encouragement. The regulatory and financial framework for SHP needs to be improved and, wherever possible, harmonised across the EU. Contrary to popular mythology, the fact that hydro represents a long-established technology does not mean there is no further room for technical development. A resurgence of small hydropower development in Europe needs to be backed by technical improvements.

The challenge of having a sustainable market for SHP requires a number of conditions:

- **Energy policy framework** - Member States should develop energy policies that clearly set out objectives regarding the development of power generation options, including small hydro power.
- **Decision-making process** - governments should establish an equitable, credible and effective environmental assessment procedure that takes into account both environmental and social concerns, with a predictable and reasonable schedule.
- **Comparison of small hydro power project alternatives** - project designers should apply environmental and social criteria when comparing project alternatives, in order to eliminate unacceptable schemes early in the planning process.
- **Improving environmental management of plants** - project design and operation should be optimized by ensuring the proper management of environmental and social issues through the project cycle.
- **Sharing benefits with local communities** - communities should benefit from local SHP projects, both in the short and the long term.
- **Increasing efficiency**- developing "high-tech" turbines and reducing the costs of very low-head schemes.

Nature like rock ramp in Austria © BOKU

This Brochure has been developed under the Thematic Network on Small Hydropower (TNSHP) Project. The Thematic Network on Small Hydropower is a European Commission - DG TREN (Transport & Energy) and Swiss Government- funded project in the framework of the EU's FP5 (Fifth Framework Programme for Research, Technological Development and Demonstration)

The TNSHP aims to identify future research and market needs of the SHP sector within the EU in order to overcome barriers and promote a better exploitation of the resource as regards costs, public acceptance, integration into energy systems, technological issues, environmental impacts and fulfilment of White Paper targets on installed capacity.

ESHA, the European Small Hydropower Association, is the European co-ordinator of this project which includes ten additional partners: ADEME (France), Studio Frosio (Italy), KÖ (Austria), SERO (Sweden), EPFL-LCH (Switzerland), MHyLab (Switzerland), SCPTH (France), ISET (Germany), IT Power (United Kingdom) and the Lithuanian Hydropower Association (Lithuania).

This paper has been prepared by the Marketing Group of the Thematic Network on Small Hydropower, coordinated by ESHA, together with the Lithuanian Hydropower Association.

ESHA - European Small Hydropower Association

ESHA is a non-profit organisation representing the interests of all actors involved in the sector of small hydropower at European level. Based in Brussels, it plays an active role at European political decision level through the dissemination of information, organisation and promotion of seminars and conferences as well as lobbying activities.

ESHA is founding member of EREC - the European Renewable Energy Council. ESHA shares its office with several Renewable Energy Industry Associations in the Renewable Energy House in Brussels, the central meeting point for renewable energy actors in the political heart of Europe.

EUROPEAN SMALL HYDROPOWER ASSOCIATION
Renewable Energy House

63-65 Rue d'Arlon
B-1040 Brussels • Belgium
T: +32 2 546 1945 • F: +32 2 546 1947
E: info@esha.be • I: www.esha.be

LITHUANIAN HYDROPOWER ASSOCIATION

Universiteto 10, Water Management Faculty,
LZUU, Kaunas-Akademija, LT-53067 Lithuania.
T: +370 37 752337 • F: +370 37 752392
I: www.hidro.lt