Overview of mini and small hydropower in Europe

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For centuries, Small Hydro Power (SHP) has been an important source of energy in all European countries possessing water potentials. With the invention of more sophisticated turbines in the twentieth century, mini and small hydro plants were used for electricity generation and became the main source of electric energy. Townships in the mountains harnessed water resources to generate electricity. Water powered mills or factories were fitted with turbines and generators and the electric power was used for productive end use.

1. THE DECLINE OF SHP DEVELOPMENT

This development continued till about 1950/1960, when the national grid was extended and reached the so far isolated SHP plants. In many cases grid supply turned only to be cheaper than operation, repair and maintenance of the SHP. In addition, stringent water management regulations and safety provisions for civil and electrical installations contributed to the early closure of many minihydro plants which, from a technical point, were still perfectly operational. In many areas the utility companies managed to enforce closure even when the supply from the grid was more costly for the user than from his minihydro plant. If production and feed-in was tolerated at all, prices paid by the utilities were so low that only the existing plants remained economical and this only, as long as no major repairs became necessary.

This situation was prevailing in most countries even after the 1974 oil shock. One would have expected that the oil crisis as well as protests against nuclear power would have opened the market for small and mini hydro. But it took more than twenty years of development and lobbying to bring about legislation and tariffs in favor or MHP.

2. NEW MOMENTUM BY THE EUROPEAN UNION

In 1997 the European Union issued the White Paper on Renewable Sources of Energy (26/11/97) outlining the future of Renewable Energy in the European Union. It covers competitiveness, environmental protection, security of supply and the promotion of energy efficiency and renewables. The paper defines a strategy and an action plan to promote renewable energy sources (RES). The target is a 12% share in total energy supply by 2010, compared to an estimated 6% in 1996.

One important feature of the Action Plan was a thorough situation analysis for Small Hydro in Europe. This “Strategic Study for the Development of Small Hydro Power in the European Union” was prepared on behalf of the European Small Hydropower Association (ESHA) under the ALTENER II project of the European Union and published in 2001[1]. It contains a comprehensive survey of present small hydro production, analyses the constraints to further development and recommends action by European legislators and the industry.

[1] Source : esha@arcadis.be. The Survey covers over 90% of the SHP production in the EU and 13 other European countries including Norway, Switzerland, Czech Republic, Hungary, Poland, Turkey and others.

3. PRESENT SITUATION OF SHP IN EUROPE

Hydropower (large and small) contributes 17%[2] to production of electrical energy in Europe, ranging from 99% in Norway, 76% in Switzerland, 65% in Austria, 51% in Sweden, down to 23% in France, 12% Czech Republic, 6% Poland, 4% Germany, 3% and less in the UK and some other countries.

Small hydropower accounts for approximately 7% of total hydro generation in Europe. The present capacity and production for 30 European countries are shown in Table 1. The total installed SHP capacity stands at 12.600 MW and production is estimated at 50.000 GWh. Leading countries are Italy, France, Germany, Spain, Sweden, Norway, Austria and Switzerland which combine 86% of SHP capacity and production.

Table 1: Installed capacity and production of SHP plants (up to 10 MW) in 30 European countries

Country	MW	GWh	Number	MW/Plant
EU Countries	1.863	35.833	13.359	0,76
Austria	848	4.246	1.110	0,76
Belgium	95	385	39	2,44
Denmark	11	30	38	0,29
Finland	320	1.280	225	1,42
France	1.977	7.100	1.700	1,16
Germany	1.502	6.253	5.625	0,27
Greece	48	160	17	2,82
Ireland	32	120	44	0,72
Italy	2.209	8.320	1.668	1,32
Luxemburg	39	195	29	1,34
Netherlands	30	60	7	4,28
Portugal	280	1.100	60	4,67
Spain	1.548	5.390	1.056	1,47
Sweden	1.050	4.600	1.615	0,65
UK	160	840	126	1,26
Non-EU Countries	2.468	10.556	4.104	0,62
Croatia	30	120	13	0,23
Czech Republic	250	677	1.136	0,22
Norway	941	4.305	547	1,72
Poland	127	705	472	2,69
Romania	44	176	9	4,89
Slovakia	31	175	180	0,17
Slovenia	77	270	413	0,19
Switzerland	757	3.300	1.109	0,68
Turkey	138	500	67	2,06
6 other non EU	73	328	158	0,46
Grand total - 30	12.617	50.635	17.463	0,72

Source: ESHA Study and ACE computations; GWh for Croatia and Romania estimated taking four (4) GWh per MW. Figures for Netherlands from Hydro Power and Dams World Atlas 2001.

[2] for OECD Europe, Source: IEA

The SHP production consists of around 17.500 individual power plants with an average capacity of 0,7 MW and a production of 2.9 GWh per year. Average capacity varies widely between countries, from over 4 MW per plant in Romania and Portugal, 2,69 in Poland, 2,82 in Greece, 2,06 in Turkey, 1,72 in Norway, 1-1,5 MW for Italy, Spain, France, Finland and UK, down to the 200-300 kW range in countries like Germany, Czech Republic, Slovakia and Slovenia. The pattern reflects the water potentials of the respective countries as well as the age of the industry: countries which started early using SHP feature a larger degree of smaller or mini hydropower plants, whereas "newcomers" like Portugal, Greece or Turkey started with plants of bigger capacity. Plants in the "traditional" SHP countries like Germany are the oldest with nearly 50% being over 60 years old. Portugal, Spain, UK, Greece and the Eastern European countries have the "youngest" installations with most plants counting less than 20 years.

Prices paid to SHP producers vary considerably among European countries with the lowest tariffs in Finland, Norway and Sweden (1,2 to 3 Eurocent/kWh) followed by a medium range of 4 to 6 Eurocent/kWh in UK, Ireland, Spain, Portugal up to tariffs which include a promotional element such as 9 Eurocent/kWh in Belgium and Switzerland, 90% of end user tariff in Greece or 65%-80% in Germany

In the future, SHP production will also benefit from carbon money under the so-called Joint Implementation mechanism. Projects located in countries where green house gas emission targets are met—first countries will probably be UK and Germany—can earn additional revenue for the emission reduction being achieved. Emission reductions can be credited for a period of five years if they are certified to fulfill the criteria of "environmental additionality". First transactions are reported by Eco Securities of UK, e.g., a forward contract for 6,1 million CO_2 in 2008-2012 worth 3 million Euro resulting from a 55-MW hydro plant in Romania, or a purchase of the environmental benefits of a 8,2-MW run-of-the-river plant in Guatemala for a ten-year period.

In most European countries the economically feasible hydro potential has been harnessed to a great extent (see Table 2). From the still untapped potential the SHP plants have a better chance for realization than large hydro with reservoirs, which face severe opposition due to their considerable environmental impact. Yet even the small and mini hydro run-of-the-river plants meet various obstacles. Although feed-in regulations are now in place in almost all European countries, the licensing and contract procedures are cumbersome and time consuming. Opposition from environmental groups, often based more on emotion than rational arguments, has to be countered. Requirements for minimum water of the original river or stream limit the exploitable flow. Demands for the installation of fish ladders or changes in civil structures in line with the natural environment can drive up civil engineering costs to levels where the investment is not any more economical.

The ESHA study estimates, that from a purely technical viewpoint, additional 2100 MW of SHP could be made available by upgrading the existing plants and restarting abandoned ones. Environmental concerns, however, would reduce this volume to around 1.100 MW. The potential for new SHP is estimated to be theoretically, i.e. without any constraints, more than 14.000 MW, mainly for the large unexploited capacities in Norway and Switzerland. Taking in account environmental and economic constraints the study assumes a potential of 6.700 MW still to be exploited. Both potentials combined add up to 7.800 MW which is 62% of present installed SHP capacity. Consequently, despite the high exploitation ratio in Europe there is still ample room for further development.

4. SHP INDUSTRY AND TECHNOLOGIES

Different from other RES_technologies, the SHP industry has been slow in exploiting the opportunities offered by the deregulation of the energy markets and the trend toward clean energy. A considerable number of small-scale SHP manufacturers closed down and some leading turbine manufacturers

discontinued their SHP production lines. The SHP industry is estimated to about 60-70 turbine manufacturers employing around 8000 people. In addition the installation of SHP plants provides work for consultants and contractors in the water engineering and electric power fields. The job creation in these fields exceeds the employment in the turbine manufacturing industry.

Table 2. Estimated Hydropower Potential and Exploitation in Europe

Countries	Econ. Feasible Potential (GWh/a)	Prodn. from Hydro Plants (GWh/a)	Exploitation Ratio (%)
15 EU Countries of which	390.000	320.000	82
Austria	50.000	38.000	76
France	72.000	70.000	97
Germany	25.000	25.000	100
Italy	55.000	52.000	95
Spain	40.000	35.000	88
Sweden	85.000	68.000	80
Selected non-EU			
Countries of which	480.000	250.000	52
Norway	180.000	120.000	67
Romania	30.000	16.000	53
Switzerland	36.000	34.000	94
Turkey	120.000	40.000	33

Source: IEA, Eurostat, Hydropower & Dams and own interpolation/computations

Investment costs differ from country to country, which reflects not only the wage level and construction cost, but also the sophistication of SHP plants. Switzerland and Germany report the highest costs namely 4.000-10.000 and 4.000-6.000 Euro/kW, respectively. At the lower end of the scale are Poland with 500–1.200, Spain and Norway with 1.000-1.500 and Greece, Slovakia and Slovenia with 1.000–2.000 Euro/kW. The average of 2.000-2.500 Euro/kW applies to 14 other countries which reported their SHP investment costs in the ESHA survey.

SHP is a proven technology which has reached a high degree of efficiency and reliability. However, the industry has developed a number of new technologies to further improve efficiency and operation. Some recent technical innovations include new designs and the use of new composite materials for low-head turbines, high speed generators and variable speed operation, submersible technologies, new types of computer-based digital controllers for remote diagnostic and automatic monitoring, and web cameras to allow regular checks on remote-control basis.

5. MARKET PROSPECTS

Europe is a market leader in SHP technology. Optimal turbine designs are available and new technical developments offer automated operation of SHP. Production costs for SHP equipment have been lowered considerably and standardization will allow European manufacturers to reduce the present price level even further. Therefore, from the technical side, there should be no obstacles for increasing SHP production and meeting the 2010 target of the EU White Paper.

The EU White Paper estimates the investment for implementing its strategy to 950.000 million Euro, a great part of which would have to be for SHP development. Taking the figure of 7.800 MW for the SHP market potential—which might be on the low side—and an average investment of 2.000 Euro per installed kW, a market volume of minimum 15.000 million Euro can be estimated.

Additional markets can be tapped in Asia, South America and Africa. Table 3 shows a relatively high hydro exploitation ratio for Europe. However, it is obvious that the Asian market offers a fantastic market potential. In contrast to Africa and South America, Asia is a vibrant market where investment capital can be raised and capable joint-venture partners are found. In India, the Ministry of Non-Conventional Energy Sources would be a good address to identify interested partners. For the 10 ASEAN countries, the ASEAN Centre for Energy (ACE) in Jakarta will establish contracts with suitable companies or institutions in any of the 10 ASEAN member countries. For China, the Hangzhou Regional Centre for Small Hydro Power could be approached as an entry point.

Table 3. Economic Hydropower Potential by Continent and % Exploitation

Region	Economic Hydro Potential	% Exploitation
Africa	12%	8
Asia	45%	25
Europe	10%	75
North & Central America	13%	75
South America	20%	30

Acknowledgments: *This paper draws on the findings of the aforementioned ESHA study, which was established in collaboration with Istituto di Economia delle Fonti di Energia, Milano/Italy and Sveriges Energiföreningars Riskorganisation, Köpping/Sweden. Other sources include: Prof. A. Zervos of EREC (presentation: Renewable Energy Development in Europe), K. Jorgensen of RISOE Roskildle/Denmark (Small Hydropower in Europe), J. Troni of Ecoscurities/UK (Hydropower within the Context of a New Carbon Economy), the 2001 Hydropower & Dams World Atlas, and various other papers.*