Sustainable markets for small hydro in developing countries

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This article analyses the current situation of SHP internationally, mainly concentrating on the mini hydro range, and factors which will allow the European SHP industry to participate in the market in developing countries. The emphasis of the paper is on seeking sustainable markets for SHP in developing countries.

Although there is still no internationally agreed definition of 'small' hydro; the upper limit is usually taken as 10 MW, and for large countries such as India and China, this rises to 25 and 50 MW respectively. In general small hydropower (SHP) is seen as having minimal environmental impacts through the use of 'run of river' schemes, see Photo (a). Also within the range of small hydro power, mini hydro typically refers to schemes below 1 MW, micro hydro below 100 kW and pico hydro below 5 kW.

World SHP capacity

Hydropower projects throughout the world provide about 19 per cent of our electricity from an installed capacity of some 741 GW and another 118 GW is currently under construction [*H&D*, 2005[1]], making hydropower by far the most important renewable energy for electrical power production. The contribution of SHP to the worldwide electrical capacity is about 47 GW and 25 GW (53 per cent) of this capacity is in developing countries.

In the SHP sector, China is the major player, driven by long-standing rural electrification programmes from the Government. The latest figures show an installed SHP capacity of 31 200 MW [IN-SHP[2]]; China alone has developed more than half of the world's small hydro capacity, and most of the capacity in developing countries. Other developing countries with significant SHP capacity are India, Brazil, Peru, Malaysia and Pakistan.

Although the cumulative capacity of the smaller end of SHP does not show up in the data, many developing countries have installed a large number of micro and pico hydro projects that are providing electrification and essential services to many thousands of households. Chinese villages have about 100 000 small micro hydro projects and rural families in Vietnam have installed 130 000 pico hydro systems.

Table 1: Installed SHP capacity by region

Region	Installed SHP capacity	Percentage
Asia	32,641	69.2
Africa	228	0.5
South America	1280	2.7
North & Central America*	2096	4.4
Europe	10,723	22.7
Australasia/Oceania	198	0.4
WORLD TOTAL	47,166	100

* USA is not included

Table 2: Renewable energy markets and typical installations in developing countries [RE World, 2003[4]]

Application	Installations in developing country markets
Rural residential and community lighting, TV, radio and telephony	• More than 50 million households served by small hydro village-scale mini grids • 10 million households with lighting from biogas • More than 1.1 million households with solar PV home systems or solar lanterns • 10,000 household served by solar-wind-diesel hybrid mini grids
Rural small industry, agriculture, and other productive uses	• Up to 1 milion wind-driven water pumps and more than 20,000 solar PV pumps • Up to 60,000 small enterprises served by small hydro village scale mini grids • Thousands of communities with drinking water from solar PV-powered purifiers and pumps
Grid-based power generation	48 000 MW of installed capacity producing 130000 GWh/year (mostly small hydro and biomass, with some geothermal and wind)

Applications of SHP in developing countries

The World Energy Assessment [UNDP/WEC, 2004[3]] estimates that between 1970 and 1990, rural electrification programmes reached about 800 million people. Many of the rural electrification programmes were through grid connection, but in addition, the

(a) Small hydro can be developed through run-of-river schemes.

amount of renewables now providing electrification in developing countries is quite substantial, as shown in Table 2.

The majority of these applications have been energized through the use of SHP, because of the applicability of the technology to mini grids and remote areas, see photo (b). SHP plants have been a mainstay of rural energy development, providing grid-based power generation as well. Most village-scale mini grids have been developed in Asia, and they are often powering small industries which provide substantial local income and jobs [RE World, 2003[4]] .

But despite these enormous efforts to improve energy services to rural populations through the extension of grids and the use of renewables, the unserved population has not decreased significantly in absolute numbers: about 1.7 billion have yet to achieve any electrification [UNDP/WEC, 2002[5]].

There is currently a shift on investment patterns in renewable energy away from traditional government and donor sources to greater reliance on private companies, and it is becoming more important to think about markets for renewable energy rather than about the technologies themselves. Also, on-going power sector restructuring in many developing countries is opening up competitive wholesale power markets and even encouraging self-generation using smaller-scale technologies [RE World[4]].

These shifts are ones that new SHP developers have to consider, and in addition, the sector must also tap into local-level capabilities (for example, provincial governments, people's organizations, small IPPs) and most importantly, local sources of financing (for example, rural banks and credit co-operatives).

International SHP markets

In the past, European companies have pioneered much of the SHP technical development through their domestic projects, and have taken a leading position in the world market for SHP equipment and installations. The EU SHP industry is multi-disciplinary and highly skilled, employing about 10 000 people, and offering a full range of products and services for the sector.

But the domestic small hydro market in Europe has become more difficult, despite national targets for clean energy production. There is an increasing number of institutional and environmental barriers to be faced in gaining permission to implement new small hydro schemes, and this is hindering progress in many developed countries [Paish, 2003[6]].

In the developing countries, it is economic growth and the increase in energy needs that is driving the increasing demand for electrification from SHP. Asia (especially China and India) is affirming itself as the leading continent for development of its hydro resources, while many Latin America countries (especially Brazil and Peru) have been active in the development of new projects. In Africa, where only 5 per cent of hydropower potential has been tapped to date, there are also good prospects.

A study by the EC in 2002 [EUREES, 2000[7]] considered new markets for SHP, particularly in developing countries and concluded that outside the EU, the following areas are the most promising:

- South and Southeast Asia;
- Eastern Europe, Russia and CIS;
- South America; and,
- some African countries.

(b) A 230 kW mini-hydro scheme for village electrification in upland Nicaragua.

Short and medium-term SHP market prospects

The detail behind the EUREES study showed that the prospects for SHP development within Europe in the medium term (up to 2010) will indeed improve through implementation of climate change polices. However, because of the relative stagnation of short-term market prospects in EU countries, the current direction for the EU industry must lie increasingly in exports and technology transfer to developing countries.

As the summary of the EUREES study [2000[7]] shows (Table 3), the greatest impetus for small hydro development is in Asia, while Latin America and some countries in Africa also have good potential, and although the receptivity to SHP may be less in South America because of the increased development of oil and gas there, the volatility of fossil fuel prices is beginning to weigh against a heavy dependence on oil and gas in this region, as everywhere else in the world.

An updated review of this study shows that the most favourable regions for export potential will still certainly be in Asia. However, prospects in Africa may be increasing because of the attention being given to SHP on this continent by some UN agencies and new encouragement to African economic growth (which will require electrification). Therefore, countries such as Uganda and Kenya may well now be considered as short-term export potentials, while Nigeria, Mozambique, Zambia and Rwanda may offer good medium term opportunities.

Examples of SHP developing country markets

Having reviewed the various markets in Table 3, the countries that currently offer strong SHP market prospects (China, India and Uganda) are reviewed in more detail.

Table 3: Countries with favourable prospects for small hydro development

Region	Short term	Medium term
Asia (excluding India and China)	Nepal, Thailand, Sri Lanka Philippines, Indonesia	Laos, Vietnam
Rest of Asia	India, China	
Latin America	Brazil, Peru	Argentina, Ecuador Colombia
Africa		Uganda
Caribbean & Pacific		Cuba

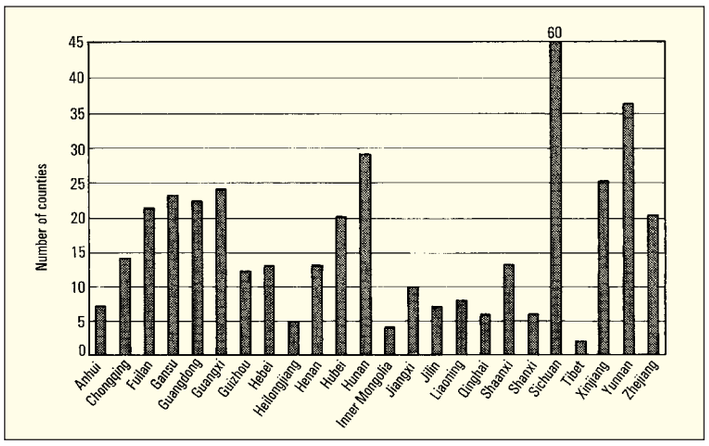

Fig. 1. China's 400 Counties electrification programme with SHP.

China

With a huge SHP resource that can be economically exploited, estimated at more than 70 000 MW, the use of SHP to achieve rural electrification has been a major characteristic of renewable energy development in China. At present, there are more than 600 counties which rely mainly on SHP for electricity (serving more than 300 million people) and there is a programme for extending this to 400 more counties (see Fig.1).

Since 2000, the rate of commissioning of new small hydro capacity has been increasing to an average of 2000 MW per year and posting healthy average annual growth of more than 7 per cent.

(c) Mass production of Chinese Pelton turbines.

(d) Local production of Chinese SHP turbine equipment.

The financing of hydropower in China is currently stable. The four major Chinese (State) banks lend to hydro projects as they are considered low risk. Meanwhile, small hydropower is attractive to commercial Chinese banks, which are very active in the sector.

China has a wide range of domestic SHP turbine manufacturers and construction companies, and these are well established, see photos (c) and (d). However, there is scope for technology transfer to improve performance and quality to European standards, and to introduce more advanced systems, particularly in the area of automated control.

Yunnan province is one example which provides an opportunity for foreign companies wanting to enter the Chinese SHP market; installed SHP in the province is currently 2250 MW and the economically exploitable hydropower resource is very large. With the need to help strengthen the grid in the south of China and transmit power to booming Guangdong, Yunnan's hydropower targets are ambitious. There is only one major manufacturer of SHP equipment in Yunnan, so equipment is imported from other provinces, and for SHP projects of less than 25 MW, approval is handled at prefecture level, making the project process fairly straightforward.

India

India has an estimated SHP potential of about 15 000 MW. So far, from 495 SHP projects, an aggregate installed capacity of 1693 MW has been installed. Besides these, 170 SHP projects with an installed capacity of 479 MW are under implementation. The database for SHP projects created by the Ministry of Non-Conventional Energy Sources (MNES) now includes 4233 potential sites, with a total capacity of 10 324 MW.

The overall policy of the Government is to encourage private sector participation in the power generation field, and the SHP sector is moving towards attaining commercial status in the country. SHP projects are increasingly becoming economically feasible. It has been recognized that SHP can play a role in improving the energy position in some parts of the country and in particular in remote and inaccessible areas.

In comparison with China, much of the demand for equipment cannot be met locally, so there are opportunities for export of systems, or joint venture manufacture under licence. There is a lack of major SHP players in India, and relatively inexperienced first generation entrepreneurs are coming forward to set up the projects; therefore, there is scope for selling SHP expertise and services.

Uganda

Hydro resources are abundant in Uganda and to date only 320 MW capacity of hydro projects have been installed (and only 16.7 MW of these are SHP). At the same time, the electrification level of the 25 million population is very low, being only 1 per cent in rural areas. The country has an enormous potential from its mini hydro energy resources at non-Nile sites which can be developed for independent grids to supply power in isolated areas of the country.

The power market in Uganda has opened up, making it easier for the private sector to participate. A key component in the power sector reform has been a new regulatory system, which will promote competition for the generation and marketing of electricity, by

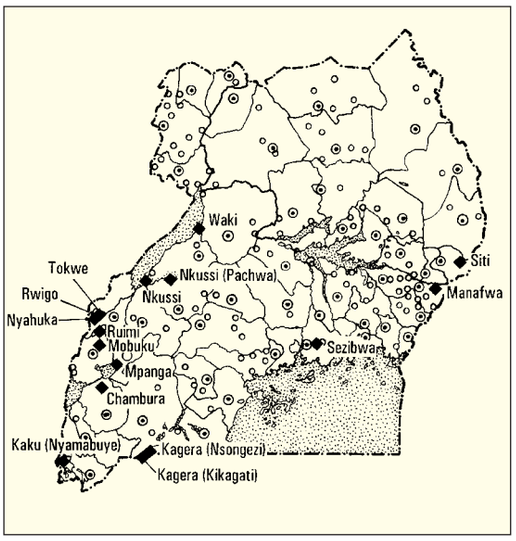

Fig. 2. Mini hydro projects studied in Uganda in 2002/2003.

enabling third parties to connect to transmission systems and use these assets.

About 71 more rivers have recently been identified for (non-Nile) mini hydro sites, with a possible total capacity about 200 MW and only a few have been developed for small power supply schemes. A summary of the best potential projects with good technical feasibility and high energy generation is shown in Fig. 2.

Uganda has also seen the benefit of the CDM in providing additional financing for SHP, with projects supported by the Prototype Carbon Fund (PCF), which will buy the carbon emission reductions. Two plants of 5.1 and 1.5 MW have recently been built and operation of the projects is being handled by a private company.

(e) Improved micro hydro site for electricity generation and rice milling in Uttarachal, India.

(f) Ugandan mini hydro resources are widespread and substantial.

Conclusions

Small hydro has already proved itself as a major contributor to electrification in developing countries and, more than anywhere, China has integrated SHP into a large proportion of the country. India and Brazil have been major players in SHP and many SE Asian countries now have many megawatts of plant installed.

Much of this activity has taken place with the involvement of European companies already, as the EU has occupied a leading position in the world SHP market. But with a stagnation of development within the EU, there is renewed emphasis for EU companies to aim at emerging SHP opportunities in developing countries, and in a market that has shifted in terms of investment patterns and the opening up of competitive power markets. The SHP sector players must also consider more local-level stakeholders and local sources of financing.

Having considered an earlier EC study that presented the countries with favourable prospects for the export of SHP products and services in the medium term, the countries that still remain the most favourable for EU export potential will certainly be in Asia, especially China and India (and increasingly Sri Lanka), but with new important potentials also in Vietnam, Indonesia and the Philippines. South America also remains a key market area, despite the attention being afforded to oil and gas developments. However, prospects in Africa may be increasing because of the recent invigorated attention being given to SHP on the continent, and Uganda, Kenya and Nigeria, among others, are emerging as important markets even in the short-term.

(g) A 7.5 kW micro hydro packaged system made by the Zheng He Water Turbine Factory, Fujian Province, China.

Overall, in approaching new developing country markets, EU SHP capabilities need to be backed up with disseminating literature widely through trade events and field missions, as well as setting up demonstration projects of EU technologies in collaboration with local industries. It is important to promote mini- and micro hydro turbine packages for remote community/village-level use (as the Chinese have done, see photo (g) and innovative and low cost low-head turbine designs such as siphonic turbine arrangements, see photo (h) ◊

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(h) A 15 kW siphon turbine demonstration in the UK.

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