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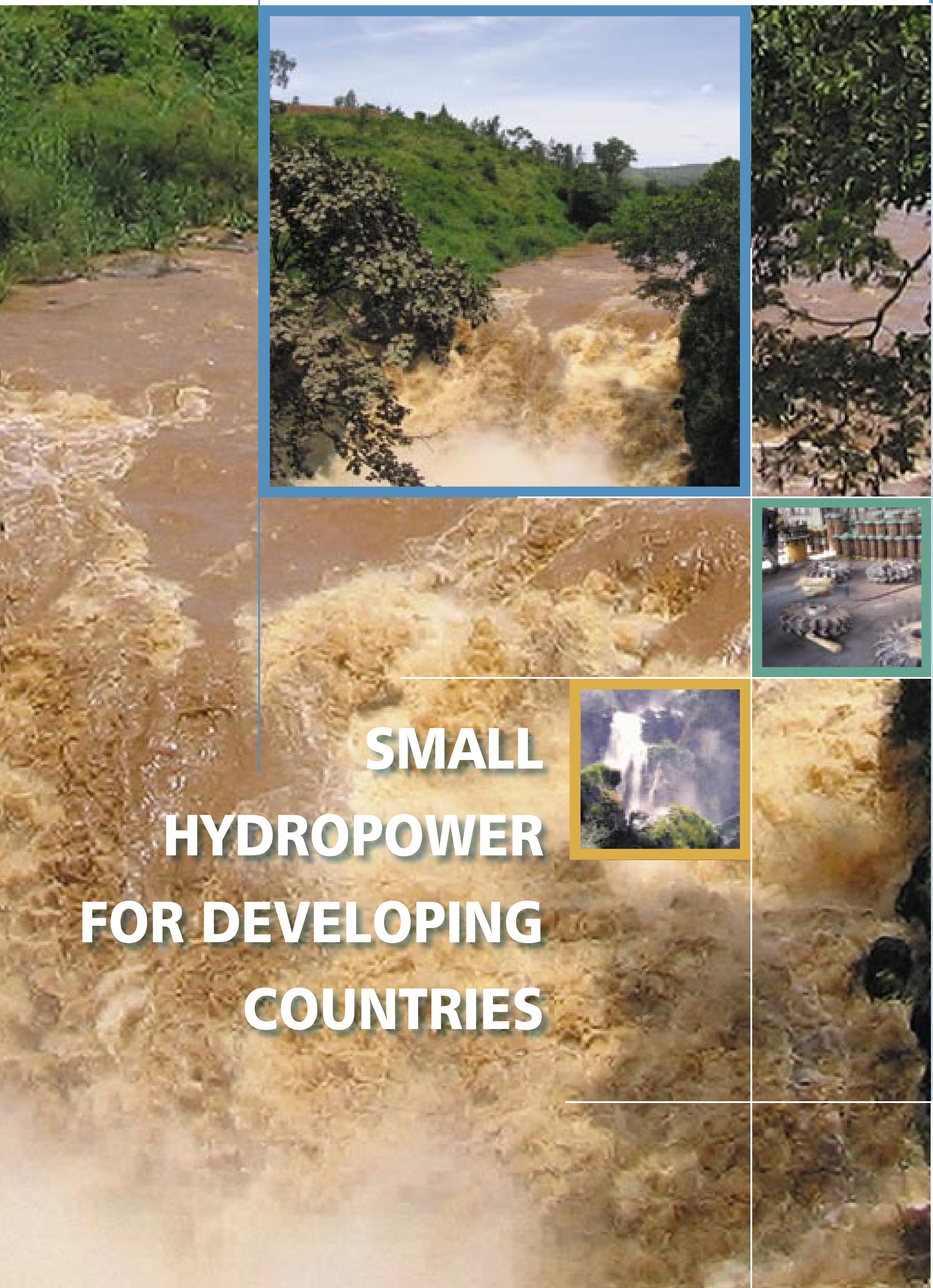

SMALL HYDROPOWER FOR DEVELOPING COUNTRIES

Small Hydropower for Developing Countries

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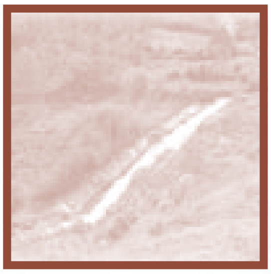
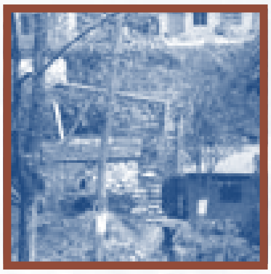




Introduction

Access to electricity is one of the keys to development, as it provides light, heat and power for productive uses and communication. Today 1.7 billion people in developing countries do not have access to electricity, most of them living in rural areas. This number is increasing despite the rural electrification programmes because they are not sufficient to cope with the population growth. Moreover, despite the fact that 80 % of the world's population lives in developing countries, they consume only 20% of the global commercial energy.

According to the World Bank, most of the world's poor people spend more than 12% of their total income on energy, that is more than four times what a middle-income family in the developed world spends. Achieving the United Nations "Millennium Development Goals" will require significantly expanded access to energy in developing countries.

Within this scenario, renewable energies must be used as a key tool in the contribution towards sustainable development in the less developed regions of the world. Small hydropower (SHP) is a renewable energy source and suitable for rural electrification in developing countries. It is a proven technology that can be connected to the main grid, used as a stand-alone option or combined with irrigation systems and can adequately contribute to the electricity needs of the developing world.

Furthermore, the substitution of conventional sources of energy (traditional biomass for cooking, diesel generators, kerosene lamps and biomass stoves) with renewable energies like SHP can help decrease CO_2 emissions - contributing to climate change mitigation - and also contribute to poverty alleviation and economic development by supplying electricity needs for lighting water pumping and operating small workshops.

The emphasis of this brochure is on seeking sustainable markets for SHP in developing countries, with the implementation of schemes that consider sustainable development of the communities concerned and tapping into mechanisms that build a strong and long-term market for SHP in key developing countries. This brochure takes four developing countries as case studies where there are currently strong SHP markets: China, India, Uganda and Brazil.

Hydropower throughout the world provides 17% of our electricity from an installed capacity of some 730GW and another 100GW is currently under construction, making hydropower by far the most important renewable energy for electrical power production. The contribution of SHP to the worldwide electrical capacity is more of a similar scale to the other renewable energy sources (1-2% of total capacity), amounting to about 47GW and 25GW (53%) of this capacity is in developing countries.

ACHIEVING THE UNITED NATIONS "MILLENNIUM DEVELOPMENT GOALS" WILL REQUIRE SIGNIFICANTLY EXPANDED ACCESS TO ENERGY IN DEVELOPING COUNTRIES

INSTALLED SHP CAPACITY BY WORLD REGION.

Source: The International Journal on Hydropower and Dams, 2004, and US DOE, 2004

Region	Installed SHP Capacity	Percentage
Asia	32,641	68.0%
Africa	228	0.5%
South America	1,280	2.7%
North & Central America	2,929	6.1%
Europe	10,723	22.3%
Australasia-Oceania	198	0.4%
TOTAL	47,997	100%

In the global SHP sector China is the major player, driven by long-standing rural electrification programmes from the government. The International Network on Small Hydropower (INSHP) latest figures show an installed SHP capacity of 31,200 MW in 43,000 stations; China alone has developed more than half of the world's small hydro capacity and represents the bulk of installed capacity in developing countries. Growth in the Chinese SHP sector remains strong at 9% per year and there are plans to develop a further 10,000MW in the next decade.

Other developing countries with significant SHP capacity are India (1,694MW), Brazil (859MW), Peru (215MW), Malaysia and Pakistan (both 107MW), Bolivia (104MW), Vietnam (70MW), the DR Congo (65MW), Sri Lanka (35MW) and Papua New Guinea (20MW), while Russia and the Central Asian states also have large amounts installed (totalling 639MW).

In the last 30 years China, Nepal, Vietnam and many South American countries have seen a large number of micro- and pico-hydro projects developed that are providing electrification to many thousands of households. Chinese villages have developed the most micro-hydro with 100,000 very small capacity units installed, amounting to 188.5MW (Chinese Rural Renewable Energy-CCRE, 2003) and rural families in Vietnam have installed 130,000 pico-hydro systems (usually 200 Watts) in the last 15 years on a purely commercial basis (Paish & Green, 2002). Yet although the cumulative capacity of such smaller hydro plants does not show up in the data, these projects are providing essential services to large numbers of populations in a wide range of countries and local topographies and conditions.

Mini-, Micro- and Pico-hydro

Although there is still no internationally agreed definition of 'small' hydro; the upper limit is usually taken as 10MW (SHP definition supported by ESHA and the European Commission) and for large countries such as India and China this rises to 25 and 50MW respectively, in general SHP has minimal environmental impacts through the use of 'run of river' schemes. Also within the range of small hydro power, mini-hydro typically refers to schemes below 1MW, micro-hydro below 100kW and pico-hydro below 5kW and although all of these technologies could be regarded as small hydro power, they have specific technical characteristics that warrant their own definition.

Generally speaking, micro- and pico-hydro technologies are used in developing countries to provide electricity to isolated communities where the electricity grid is not available, whereas mini-hydro tends to be grid connected. In most cases, no dam or reservoir storage is involved in pico-, micro- and mini-hydro schemes.

Micro- and pico-hydro can also differ from mini-hydro in a number of ways, for example in the first two case, scheme design can be approached on a per household basis or at village level often involving local materials and labour whereas mini-hydro schemes require traditional engineering approaches. Also, mini-hydro schemes will usually require an access road to be built for construction materials and heavy electro-mechanical equipment to be delivered to the site, whereas most micro-hydro schemes can be built with purely manual labour in more remote locations.

A crucial difference is in terms of load control. Since the electricity from micro- and pico-hydro schemes is supplied directly to households, there is no large grid to control the frequency and voltage of the supply, hence a local load controller is necessary. For pico-hydro, the turbine/generator set can be bought as a modular, off-the-shelf unit, unlike the equipment for larger schemes (micro-hydro and upwards) where the turbine has to be specifically designed for a particular site.

SHP Technology Suitable for Developing Countries

7.5kW Micro-Hydro package system, made by a Chinese water turbine factory *(©IT Power)*

Hydraulic turbines are generally classified as high-head, medium-head or low-head machines, but this is relative to the size of machine: what is low head for a large turbine can be high head for a small turbine; for example a pelton turbine might be used at 50m head with a 10kW system but would need a minimum head of 150m to be considered for a 1MW system.

Turbines are also divided by their principle of operation and can be either impulse or reaction turbines. The rotor of the reaction turbine is fully immersed in water and is enclosed in a pressure casing. The runner blades are profiled so that pressure differences across them impose lift forces, akin to those on aircraft wings, which cause the runner to rotate. In contrast, an impulse turbine runner operates in air, driven by a jet (or jets) of water, and the water remains at atmospheric pressure before and after making contact with the runner blades.

However, the disadvantage of impulse turbines is that they are generally unsuitable for low-head sites because these types of turbines require higher head to run at a desirable speed for connection with the generator. Only on very small sites, the crossflow can be used down to 4m and small turgos or multi-jet peltons down to perhaps 20m.

Two particular attractions of the crossflow turbine have led to its widespread popularity for micro-hydro applications, although it has the lowest peak efficiency of the common turbine types (70-80%). Firstly, it is a design suitable for a wide range of heads and power ratings. Secondly it can be manufactured relatively easily, a feature which is of particular importance to developing countries. The runner blades, for instance, can be fabricated from lengths of pipe cut into strips.

The crossflow and pelton turbine types are the most widely adopted turbine technology for local manufacture in developing countries. This is also because impulse turbines are better suited than reaction turbines to micro-hydro applications. They have the following advantages:

- more tolerant of sand and other particles in the water;
- better access to working parts;
- no pressure seals or glands around the shaft;
- easier to fabricate and maintain;
- better part-flow efficiency.

Classification of Impulse and Reaction Turbines

Turbine Type			Head Classification
	High (>50m)	Medium (10-50m)	Low (<10m)
Impulse	Pelton	Crossflow	Crossflow
	Turgo	Turgo	
	Multi-jet Pelton	Multi-jet Pelton	
			Francis (open-flume)
Reaction		Francis (spiral case)	Propeller
			Kaplan

In certain countries such as China, Peru, Brazil, India and Nepal, the manufacture and installation of SHP projects of various ranges has established their own strong industries and capabilities in the sector and because the activity has often taken place in the provincial rural areas, this has significantly contributed to local development and gainfully employed many thousands of people.

230kW mini-hydro scheme for village electrification in Nicaragua *(©IT Power)*

THE CROSSFLOW AND PELTON TURBINE TYPES ARE THE MOST WIDELY ADOPTED TURBINE TECHNOLOGY FOR LOCAL MANUFACTURE IN DEVELOPING COUNTRIES

Applications of SHP in Developing Countries

The World Energy Assessment estimates that between 1970 and 1990, rural electrification programmes reached about 800 million people. Much of the rural electrification programmes were through grid connection, but in addition the amount of renewables now providing electrification in developing countries is quite substantial.

ENVIRONMENTAL HEALTH AND SOCIAL BURDENS OF TRADITIONAL FUELS ARE AVOID BY SWITCHING TO ELECTRICITY FROM SHP

Renewable energy markets and typical installations in developing countries
Source: Martinot 2003

Application	Installations in developing countries market
Rural residential and community lighting, TV, radio and telephony	Over 50 million households served by small hydro village-scale minigrids 10 million households with lighting from biogas
	Over 1.1 million households with solar PV home systems or solar lanterns
	10,000 households served by solar-wind-diesel hybrid minigrids
Rural small industry, agriculture,	Up to 1 million wind-driven water pumps and over 20,000 solar PV pumps
and other productive uses	Up to 60,000 small enterprises served by small hydro village-scale minigrids
	Thousands of communities with drinking water from solar PV-powered purifiers and pumps
Grid-based power generation	48,000 MW installed capacity producing 130,000 GWh/year (mostly small hydro and biomass, with some geothermal and wind)

The majority of these applications have been energized through the use of SHP, because of the applicability of the technology to minigrids and remote (often mountainous) areas as well as for grid-based power generation, where SHP plants have been a mainstay of rural energy development for many years. Village-scale minigrids can serve hundreds of households in settings where there are sufficiently clustered end-users; most village-scale minigrids have been developed in Asia on the basis of small hydro, particularly in China, Nepal, India, Vietnam and Sri Lanka where they are often also powering small industries that provide substantial local income and jobs.

Benefits of SHP

SHP for electrification in rural areas can attain many potential benefits. Apart from the environmental, health and social burdens of traditional fuels which are avoided by switching to electricity, direct economic benefits flow from the use of electricity in productive applications, such as irrigation, crop processing and food preservation.

Employment opportunities have increased as a result of the encouragement of productive applications and electrification has given increased potential for the development of business enterprises. For users who previously depended on traditional energy sources, the greater efficiency of electricity supply provides direct financial savings. At a national level, where electricity substitutes paraffin or diesel, it is possible that there would be foreign exchange savings on imported fuel. Where electricity acts as a stimulus to agriculture, commerce and industry, the indirect economic spin-offs in terms of value-added and job creation have been reported as significant (WEC, 1999).

But despite these enormous efforts to improve energy services to rural populations through the extension of grids and the use of renewables such as SHP in the past thirty to forty years, the un-served population has not decreased significantly in absolute numbers – about 1.7 billion have yet to achieve any electrification. This amounts to roughly 400 million households, or 40% of developing countries population, which remains a substantial market.

Inside af 5kW micro-hydro powerhouse used for rice milling, Uttarachal, India
(©IT Power)

Investment Patterns

There is currently a shift on investment patterns in renewable energy away from traditional government and donor sources to greater reliance on private firms and it is now more important to think about markets for renewable energy rather than simply about the technologies themselves. The old technology-oriented paradigm focused on technology demonstrations and economic viability is being replaced by a new focus on market assessment, policy and institutional issues, and demonstrations of sustainable business models.

Ongoing power sector restructuring in many developing countries is opening up competitive wholesale power markets and even encouraging self-generation by end-users using smaller-scale technologies. A growing share of the power generation field is being handed to private power developers and this is affecting the prospects (both positively and negatively) for grid-connected renewable energy, where SHP is or can be a major player.

These shifts are ones that new SHP developments have to consider and in addition countries such as India and Brazil have policies to facilitate renewable power generation, such as 'wheeling' electricity to end-users via the utility's transmission lines, where the technology SHP is well placed to benefit. (Martinot, 2003).

The SHP sector must also tap more into local-level capabilities (as has been demonstrated in Nepal, the Philippines and Peru), involving the lower tiers of government, rural electric utilities, people's organizations, NGOs, small IPPs and most importantly, local sources of financing such as rural banks and credit co-operatives and even local entrepreneurs.

International SHP Markets

In the past, European companies have pioneered much of the SHP technical development through their domestic projects, and in recent years 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. Of the suppliers of turbines less than 10MW in size, the largest number from one economic 'block' are companies in the EU (46 out of 112) compared to 27 USA and Canadian companies.

But the domestic small hydro market in Europe has become more difficult despite national targets for renewable energy production. There are 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. Only Eastern European countries and Russia are showing increasing activity in the development of small hydropower.

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 development of new projects. In Africa, where only 5% of hydropower potential has been tapped to date, there are also good prospects.

The EUREES study by the EC in 2002 considered new markets for SHP, particularly in developing countries, based on 3 selection criteria important for exporters; (i) funding (project finance packages, export credit guarantees), (ii) host government situations (stability, regulatory framework), (iii) future market (hydro resource, local competition). It concluded that outside the EU, the following areas are the most promising, although the limitations to European expansion in these areas include financing, lack of stable framework and finding a reliable local company to co-operate with:

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

IN THE DEVELOPING COUNTRIES IT IS ECONOMIC GROWTH AND THE INCREASE IN ENERGY NEEDS THAT IS DRIVING THE INCREASING DEMAND FOR ELECTRIFICATION FROM SHP

Improved Micro-Hydro site for electricity generation, India. *(© IT Power)*

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 and targets, which will increase the value of renewable energy, and through an expected increase in refurbishment work for old plants. However, because of the relative stagnation of short-term (in the next few years) small hydro market prospects in EU countries, the current direction for the EU industry must lie increasingly in exports and technology transfer to countries and regions outside the EU.

The greatest impetus for SHP development is in Asia, especially China and India. This region has the best hydraulic resources, a major need for power, and is the recipient of large amounts of financial support for rural electrification, also backed by government initiatives. Latin America and some countries in Africa also have good potential for hydro developments, and although the receptivity to SHP may be less in South America due to 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.

The most favourable regions for export potential will certainly be in Asia. However, prospects in Africa may be increasing due to the attention being given to SHP in this continent by agencies such as the UNDP and UNIDO, the new encouragement by the EU and USA to African economic growth (which will require electrification), the current high price of electricity from imported oil and gas, and an increased environmental awareness from within African nations that the traditional large dams will not be the appropriate way of developing their hydraulic resources. 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.

Target countries for favourable prospects for exports of SHP

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

THE GREATEST IMPETUS FOR SHP DEVELOPMENT IS IN ASIA, ESPECIALLY CHINA AND INDIA

SHP Policy Frameworks

The development of good policy frameworks – for example, (i) national policies for rural access to electricity including institutional, legal and financial frames; (ii) planning of target areas; (iii) capacity building for users and for local private sector; (iv) communication activities of the benefits for SHP as a sustainable tool for social and economic development - is a key issue for the success of rural electrification small hydropower.

The history of SHP development in China is taken as an example of a number of economic and policy dimensions that have encouraged the rapid expansion of SHP technology, which could be emulated in other countries. The following three factors were found to be the major contributors:

Governmental Preferential Policies

The Chinese government has given numerous preferential policies and measures to encourage SHP development. These include tax reductions, soft loans and grants, the promotion of private firms to invest in SHP stations, and policies to protect supply areas and private property.

THE DEVELOPMENT OF GOOD POLICY FRAMEWORKS IS A KEY ISSUE FOR THE SUCCESS OF RURAL ELECTRIFICATION BY SHP

Indigenous Manufacturing Capability

Since the 1970s, when SHP in China saw huge growth rates of 20% per year and there was not enough manufacturing capability to develop the required 200-300 MW total installed capacity annually, the Chinese government mandated certain counties and provinces to develop their own SHP equipment and then continued to promote local manufacturing to reduce overall costs. Local industry was eventually able to manufacture equipment for a capacity addition of more than 3,000 MW per year and today China is able to satisfy its domestic needs and exports hydro equipment to other countries.

Recognizing the advantages of SHP over Large Hydropower

China has long realized that SHP has benefits that cannot be achieved through large or mega hydro stations, for example SHP construction results in fewer environmental impacts and does not require the displacement of people. In addition, SHP technology is not complex and can be easily understood and transferred to a variety of communities. Since most SHP stations have their own supply areas and local grids, they can supply electricity to local people as well as connect to larger grids. This enables these stations to maximize profits by purchasing electricity from the large grid in times of low generation and sell it back when there is excess generation capacity.

Overview of a 5.4 MW SHP station, Zejiang Province, China *(© IT Power)*

Examples of SHP Developing Country Markets

China

China has 17% of the earth's hydropower resource and has installed over half of the world's SHP capacity (31,200MW). The economic SHP resource is estimated to exceed 70,000MW. 90% of the number of stations and 30% of this total capacity is in the mini-hydro and micro-hydro range.

China SHP stations by installed capacity (2001)

Type		Micro	Mini	Small	Total
Station	Number	18,944	19,609	4,427	43,027
	Percentage	44.0%	45.6%	10.4%	100.0%
Installed capacity	MW	687	7,171	18,404	26,262
	Percentage	2.6%	27.3%	70.1%	100.0%
Annual output	GWh	1,860	20,245	65,036	87,141
	Percentage	2.1%	23.2%	74.6%	100.0%

The use of small-scale hydropower to achieve rural electrification is a major characteristic of renewable energy development in China, started in the 1950s with strong central government lead. At present, there are over 600 counties (accounting for 30% of all of China's counties) that rely mainly on small-scale hydropower for electricity (serving over 300 million people) and there is a programme for rolling this out to 400 more counties.

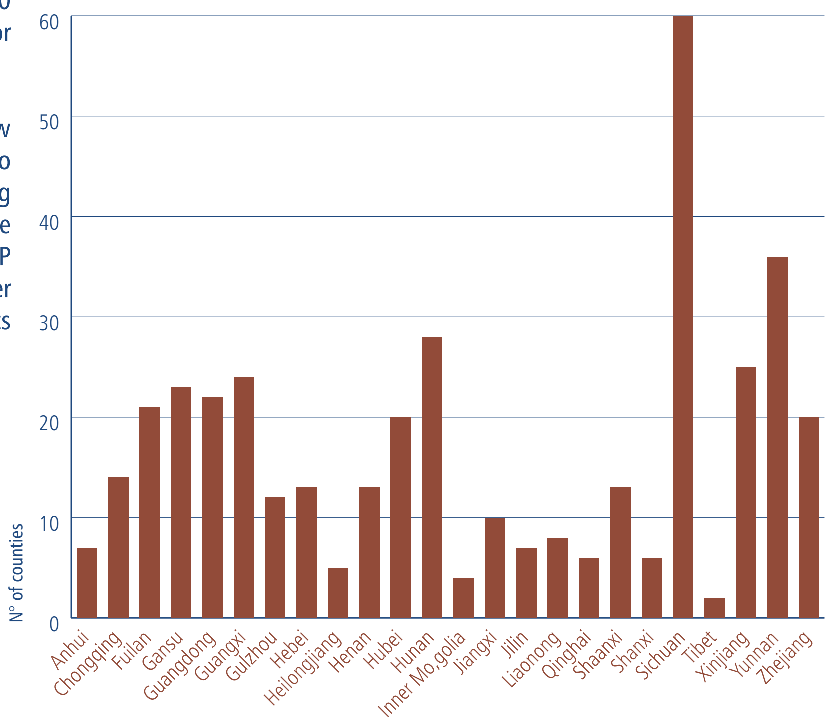
Since 2000, the rate of commissioning of new small hydro capacity has been increasing to an average of 2,000 MW per year and posting healthy annual average growth of over 7%. The country has built up such an experience in SHP that it now has a strategy of 'going-out' to other developing countries to help develop projects (usually with Chinese technology).

Financing SHP in China

Each year, the Chinese Government invests EUR30 million in the development of small-scale hydropower, attracting additional substantial investments from local governments, enterprises, and individuals of a further EUR10 billion. However with declining government investment in the sector, other sources are often required to bring targeted projects to development, and the Clean Development Mechanism (CDM) is one avenue that Chinese developers are now considering.

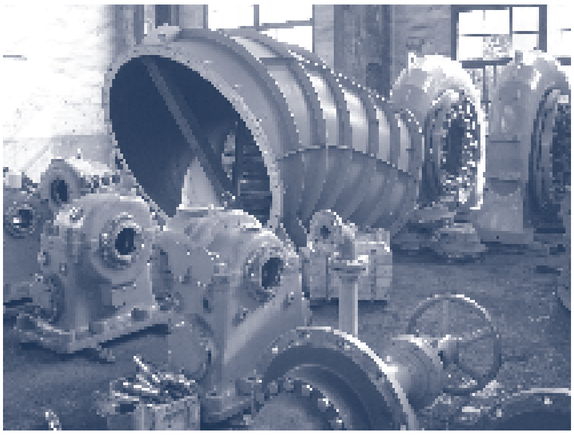
The financing of hydropower in China is currently stable. The 4 major Chinese (state) banks lend to hydro projects as they are considered low risk and their loan terms are usually 3-5 years and financing negotiations take only 3 months. Some companies already have credit ratings up to fixed amount of capital which enables them to borrow up to this ceiling in one month. Meanwhile small hydro power is attractive to commercial Chinese banks, who are very active in the sector. The Ministry for Water Resources also continues to provide low interest loans for SHP development, worth about RMB300 million per year.

400 counties electrification program with SHP



EACH YEAR, THE CHINESE GOVERNMENT INVESTS EUR30 MILLION IN THE

Mass production of Chinese pelton turbines *(©IT Power)*



Local production of Chinese SHP turbine equipment *(©IT Power)*

SHP Policy in China

A new 'Renewable Energy Promotion Law' was approved by the National People's Council in February 2005 which targets 10% of the country's electricity generation being supplied by renewables by 2020. This is ambitious given that China's GDP may quadruple in the next 15 years, (perhaps) requiring the total grid installed capacity to (perhaps) have reached 1,000GW. Nevertheless, experts have suggested that 60,000MW of SHP capacity be developed from the yet untapped small hydro resources and certainly, with the enactment of this law in 2006, faster SHP development can be expected.

SHP Industry in China

China has a wide range of domestic SHP turbine manufacturers (about 80 in total) as well as construction companies that specialize in SHP infrastructure and these have been supported since the early 1960s to deliver the technology to the sector and are therefore well-established. However there is scope for technology transfer to improve performance and quality to European standards, and introduce more advanced systems particularly, in the area of automated control.

In April 2003, the Ministry of Water Resources (MWR) released guidelines for the modernization of hydropower systems in rural China, which provide further direction and standards for small hydropower development. Its overall objective is to modernize 50% of rural hydropower plants by 2010, and modernize 100% of the rural hydro sector by 2015.

The case of Yunnan province

Yunnan province in the south-west of China is a good case study and provides opportunity for foreign companies wanting to enter the Chinese SHP market; the province has abundant hydro power resources and an excellent track record and high annual operating hours for existing plant. The installed hydro capacity in Yunnan is currently 11,710MW of which 2,250MW is SHP (19%). The economically exploitable hydropower resource is very large at 97.95 GW (1⁄4 of China's potential), however the percentage of hydropower exploited is still low at 7.5%. Yunnan's hydropower targets are 18,800MW by 2010 and 62,000MW by 2020 (admittedly much of this large hydro), to help strengthen the grid in the south of China and transmit power from the west to load centres in Yunnan and for export to Guangdong, which has suffered power shortages in recent years. There is only one major manufacturer of SHP equipment in Yunnan, so equipments are imported from other provinces. For SHP projects less than 25 MW, approval is handled at prefecture level, making the project process fairly straight-forward.

India

India has an estimated SHP potential of about 15,000 MW. From 495 SHP projects an aggregate installed capacity of 1,693 MW has been installed to date. Besides these, 170 SHP projects with an installed capacity of 479.26 MW are under implementation. The share of SHP in all renewables is 31%, only wind is larger at 55%.

Renewable Energy in India.
Source: MNES-Indian Ministry of Non-Conventional Energy Sources

Source/Systems	Estimated Potential (MW)	Cumulative installed capacity (MW)
Wind Power	45,000	2,980
Biomass Power	16,000	290.5
Bagasse Co-generation	3,500	473.03
Small Hydro (up to 25 MW)	15,000	1,693.64
Waste to energy (Municipal Solid Waste)	1,700	17
Waste to energy (Industrial Solid Waste)	1,00	29.5
Solar Photovoltaic	20 MW per sq.Km.	2.8
		5,450.47

A database has been created for most potential sites by collecting information from various sources and the State Governments. The database for SHP projects created by the Ministry of Non-Conventional Energy Sources (MNES) now includes 4,233 potential sites with an aggregate capacity of 10,324 MW.

India has exploited 30% of its low-head SHP but there is still minimal development in remote and mountainous areas. Overall, the share of hydro in the Indian electricity grid mix has dropped from 50% to 25% in the last few decades. Yet hydropower is highlighted as playing a key role in expanding the current power capacity, which is 20-30% below demand.

Improved Micro-Hydro site for electricity generation, India. *(© IT Power)*

SHP Policy in India

The overall policy of the government is to encourage private sector participation for the power generation field and the SHP sector is moving towards attaining commercial status in the country. SHP projects are increasingly becoming economically viable. It has been recognised 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. SHP in remote areas can be focussed on contributing to a national clean energy strategy as well as electricity for processing, communications and health care needs.

Financing SHP in India

A special incentive package has been developed for the promotion of the SHP programme in the North-Eastern states (Sikkim, J&K, Himachal Pradesh and Uttaranchal), giving capital grants per MW. The capital support is to cover 90% of the project cost with support limits for various ranges of projects (below 100 kW, 100kW to 1MW and up to 25 MW).

The development of commercial projects has been the emphasis in 2003-04 covering projects up to 25 MW with subsidy from MNES. In total, 47 commercial projects with a total capacity of 164 MW have so far been supported and 35 of these (in Andhra Pradesh, Karnataka and Himachal Pradesh) have been commissioned by the private sector.

The Indian Renewable Energy Development Agency (IREDA) is the financial institution that provides the loans for setting up SHP projects. It has a strong track record with US$128 million disbursed for 118 SHP projects (180MW) so far and is currently handling a second World Bank financing package designed for SHP.

5kW crossflow turbine, India. *(© IT Power)*

Preliminary survey to evaluate suitable sites for SHP in remote areas without electricity generation, Togo. *(© Studio Frosio)*

The MNES has been implementing a scheme of providing financial support for Renovation / Modernisation and capacity up-grading of old SHP Stations. The main aim of the scheme is to renovate the plants, to extend their life with improved performance and reliability. The MNES has so far supported 12 projects for their renovation and modernisation and the scheme has been rationalised and extended to cover projects up to 25 MW.

SHP Industry in India

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

Certain European manufacturers already have joint ventures in place. Norway has a bilateral agreement to supply turbines, and USA and China are both strongly promoting their technology.

Uganda

Hydro resources are abundant in Uganda, especially along the Nile and to date only 320MW capacity of hydro projects have been installed (and only 16.7MW of these are SHP). At the same time, the electrification level of the 25M population is very low with only 1% electrified in rural areas.

Uganda also has an enormous potential from its mini-hydro energy resources in non-Nile sites, which have not been fully exploited and can be developed for independent grids to supply power in isolated areas of the country. A recent report from the Ugandan Renewable Energy Association, summaries available information from reports on some of potential mini-hydro sites for development.

SHP Policy in Uganda

The power market in Uganda has opened up, making it easier for the private sector to participate. Power generation, transmission and distribution used to be the monopoly of Uganda Electricity Board (UEB). Under the Electricity Act, 1999, of the Power Sector Reform and Privatization Strategy, the Electricity Regularity Authority (ERA) was established to regulate generation, transmission, distribution, sale, export, import and supply of electric energy.

A key component in the Power Sector Reform has been a new regulatory system, undertaken by the ERA, which will promote competition for the generation and marketing of electricity by enabling third parties to connect to transmission systems and utilise these assets. A tariff structure has been formulated and the charge rate and terms and conditions of electricity services provided by transmission and distribution companies investigated.

The non-Nile mini-hydro sites are available on about 71 rivers, identified in a detailed inventory (supported by the Royal Netherlands Embassy and ADB) having good potential for power production. The total capacity of these sites is about 200MW. Only a few have been developed for small power supply schemes.

Financing SHP in Uganda

Although recent studies indicate that the market for SHP in Uganda is indeed strong, a key concern for Ugandan SHP projects will be on the financing aspect. Access to public

ACCESS TO PUBLIC SECTOR FUNDING FOR SHP IS MORE IMPORTANT IN AFRICA THAN OTHER REGIONS

Generators shed, Mukngwa, Rwanda. *(© MHyLab)*

sector funding for SHP is more important in Africa than in other regions, as there has been a marked decrease in international lending to African nations ($1B in the mid-1990s to $100M in 2002). Public-private co-operation with bilateral concessional funding is a model that has been suggested for Uganda and could also apply to many nations of the continent.

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 and management of the carbon abatement is being handled by a private company (Ilskog, 2004).

A German SHP turbine-manufacturing firm have recently proposed that mini-hydro power stations (between 1 - 1,000kW of power) that do not need dams to operate, have a strong potential to supply rural areas in Uganda to ease the high demand on the national electricity grid, which has generation capacity falling short of demand by 120MW in the evening peak and 25MW during the day (African Energy 2005).

Brazil

Hydropower is a major energy resource in Brazil and hydro generating capacity already provides 88% of Brazil's electricity. According to the World Energy Council, between 1980 and 1999 capacity more than doubled to 11GW yet only 35% of the huge potential has been harnessed so far, especially along the many rivers in the north.

Small-scale hydro in Brazil is defined as plants with a capacity of 1 to 30 MW and an area of reservoir limited to 3km. By 1999 there were 331 small hydro plants in operation, totaling 604.6 MW, most of them dating from the 1910s to the 1950s (Guilherme et al, 1999). Since then approximately 300MW of new SHP capacity has been built, bringing the total to about 900MW. Another 1,400MW capacity has been proposed for development before 2008 and these are currently in various stages of permissions, approval and financing.

SHP Policy in Brazil

Within the 1998 Law for SHP which created incentives for the sector (Law 9658), owners of plants can sell power directly to large consumers (who demand over 500kW), they can use the grid system with at least a 50% discount on distribution charges and can avail of special funds to generate energy in remote areas (especially in the north).

SHP companies supplying hydroelectric technology that have already entered the Brazilian market are mainly from USA and Canada, Spain as well as the long-established local branches of large companies such as ABB and Siemens.

Financing SHP in Brazil

The emphasis for SHP development is currently in the north and northwest, which has a large concentration of rivers and remote villages along them. The aim is to replace diesel generators in these villages and every SHP project can qualify for carbon financing.

The Federal Government provides a number of financial incentives to owners/developers of small-scale hydro schemes and various international banks and agencies are also active in the sector in Brazil. The Program for Energy Development in States and Municipalities (PRODEEM) is a recent example of a public–private partnership initiative that has supported small-scale renewables for electrification of remote communities.

USAID is running an energy program between 2003 and 2008 in Brazil worth $1.2 million this year, the primary goal of which is to reduce greenhouse gases by developing and encouraging biomass fuels, solar and wind power, and small-scale hydropower plants. A secondary goal is to reduce poverty and improve the quality of life for communities that currently lack access to reliable energy.

Conclusions

Small hydro power has already proved itself as a major contributor to electrification in developing countries with over 50 million households and 60,000 small enterprises served by small hydro at the village-level as well as projects feeding useful amounts of power into grid networks. More than anywhere, China has integrated SHP into a large percentage of the country (1,000 out of 2,300 'counties') and hundreds of millions rely on minigrids powered by small hydro plants. India and Brazil have been major players in SHP and many Asian countries now have many megawatts of plant installed.

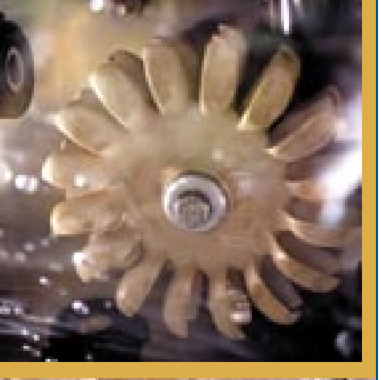
Much of this activity has taken place with the involvement of European companies already, as the EU has occupied a leading position in the world SHP market. But with a stagnation of development within the EU, there is a renewed emphasis for EU companies that offer SHP products and services to aim at emerging opportunities in new developing countries, and at a market that has shifted in terms of investment patterns (away from donor sources to greater reliance on private firms) and power sector restructuring that is opening up competitive power markets. The SHP sector players must also consider more local-level stakeholders and local sources of financing, as a main condition for success.

The countries that still remain the most favourable for EU export potential will certainly be in Asia, especially China and India and now Sri Lanka, but with new important potentials in Vietnam, Indonesia and the Philippines. South America also remains as a key market area, despite the attention also being afforded to oil and gas developments. However, prospects in Africa may be increasing due to the recent invigorated attention being given to SHP in the continent, and Uganda, Kenya and Nigeria, amongst others are emerging as important markets even in the short-term.

In approaching new developing country markets, EU SHP capabilities need to be backed up with generating good literature and disseminating it widely through trade events and field missions, as well as setting up demonstration projects of EU technologies in collaboration with local industries, as part of a technology transfer initiative. It is particularly important for example to promote mini- and micro-hydro turbine packages for remote community/village-level use, innovative and low cost low-head turbine designs such as siphonic turbine arrangements that saves on civil works costs and freestream hydro turbines driven by river flow that rely purely on kinetic energy only and require no head.

Overall, SHP can contribute to achieving the "Millennium Development Goals", but there are key conditions that are needed in order to succeed in SHP electrification in developing countries:

- To create national institutional, legal and financial frameworks for rural electrification,
- To identify target areas and define SHP electrification programmes
- To strengthen local technical capacities
- To establish higher level of expertise in the local agencies of funding institutions,
- To expand support for local networking between stakeholders (rural developers, bankers, institutional and private sectors, etc.)
- To develop tools for local private sector development.



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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.

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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.

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Technical expertise at IT Power encompasses small hydro, wind, solar PV, solar thermal, tidal, wave and biomass systems. IT Power also has extensive experience on climate change issues, financing and activities supporting the Millenium Development Goals.

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