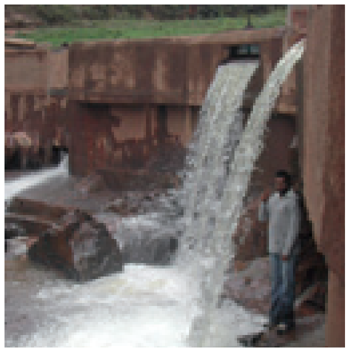
UNIDO EVALUATION GROUP

Independent Thematic Review

UNIDO Projects for the Promotion of Small Hydro Power for Productive Use



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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
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Executive Summary

This independent review of UNIDO projects in the area of Small-Scale Hydropower (SHP) responds to an ad-hoc request of the Director-General of UNIDO. The review was carried out by Peter Loewe, Senior Evaluation Officer at the UNIDO Evaluation Group.

As of October 2008, the operational status of the 24 SHP sites in 14 countries can be summarized as follows:

- Five sites are operational, three of which are 1-2 kW pico-hydro installations
- Two sites in Nigeria are finalized but their commissioning is pending
- Two sites in Tanzania and Kenya were operational but operation is suspended due to technical or other problems
- The operation of the site in India is suspended because grid electricity has become available at this site
- Four sites in Nigeria and Rwanda are under construction
- The finalization of the site in Mali (3 kW) is suspended due to technical and other problems
- The equipment for the four sites in Sri Lanka, Tanzania, Ghana and Uganda has been delivered but not installed for various reasons
- The construction of the site in Cambodia is underway but the available budget is unlikely to be sufficient to complete the work
- Four sites in Uganda, Sierra Leone, Zambia and Ecuador are at the feasibility stage, the latter for more than four years

The following main findings emerge from the independent review:

<u>A collection of "pilot projects" on a weak programmatic basis</u>

UNIDO pursues SHP "pilot projects" since many years and in a relatively large number but there is no evidence of systematic programmatic planning, collection and analysis of data, systematic review of literature or analysis of relevant evaluations from other donors. With the exception of Ecuador, the hydropower resources of target countries were not systematically mapped and assessed, although this is necessary to assure the relevance and replicability of a pilot project. On a global scale, UNIDO tends to assess the SHP potential quite optimistically but this optimism is not based on a systematic assessment of the *economically viable* SHP potential world wide.

<u>Weak feasibility studies</u>

The analytical weakness is also reflected by the relatively superficial feasibility studies or the lack of such studies for the individual project sites. Basic parameters such as the perennial availability of hydropower resources, silt load or proximity of the central grid were not properly assessed. These shortcomings led to costly design corrections during project execution, maintenance problems, and under-equipping of some of the sites or even technical failures. At none of

the sites, the electricity production costs were properly estimated by ex-ante feasibility studies or calculated ex-post by “as-built studies”.

Weak reporting, accountability and learning mechanisms

The execution of the SHP activities has been characterized by weak reporting, accountability and learning mechanisms. Regular project progress reports are not available and most self-evaluation reports are of poor quality. The results of “pilot projects” are not analyzed in a systematic manner and no explicit lessons are drawn from the projects. The delivery of outputs and deliverables mentioned in project documents is not verified and recommendations from evaluations are not followed through. There is no evidence of systematic learning at unit level or transfer of experiences between individual project officers.

Technology supply driven approach

In many countries, the starting point of UNIDO activities has been the donation of turbines from China, leading to a technology supply driven approach, although turbine cost is, in general, insignificant as compared to the overall project cost. In four countries, Chinese turbines were delivered but not yet installed. Sri Lanka has been an extreme case, where the decision to import a donated turbine instead of using a nationally manufactured turbine delayed the project by more than a year, caused significant additional cost and was counterproductive because failing to support the local manufacturing capacity.

“Productive use” does not develop spontaneously

Despite UNIDO’s in principle commitment to the “productive use” of electricity, the practical focus of activities has been on rural lighting. At none of the pilot sites was there a significant degree of “productive use”. The mere availability of electricity did not lead to productive use, an observation that is in line with the scientific literature and evaluations by the World Bank and other donors. UNIDO has not given sufficient attention to the widely accepted fact that rural electrification programmes, whether renewable energy based or not, should be accompanied by a package of dedicated activities for the promotion of “productive use”.

The “anti-poor pattern” of rural electrification

In many countries rural electrification is of high priority and the national central grid is rapidly advancing into rural areas. However, the advancement of the grid to rural areas does not automatically lead to better access to electricity for the poor. Bringing electricity to remote places may be a priority of the local elite but this does not necessarily lead to electricity access for the poor. Millions of poor people living nearby the grid cannot afford grid connection. This is why a recent impact evaluation of the World Bank emphasizes the “anti-poor pattern” of rural electrification. These considerations apply also to SHP based electrification schemes because SHP electricity is not necessarily cheaper than grid electricity.

Hidden subsidies

Implicitly, UNIDO seems to adopt a policy of installing SHP plants for free, not accounting for investment costs and, hence, setting electricity tariffs below cost. This policy of hidden subsidies seems to be partly unconscious, due to the deficient collection of economic data and analysis of cost structures. Even if in certain circumstances there may be a case for subsidies, such subsidies should be targeted, transparent, effective, and sustainable and rooted in policy priorities. In practice, the hidden subsidies policy applied by UNIDO may even jeopardize attempts by governments and other donors to develop commercially viable and private sector based user models.

Bias towards community based user models leads to sustainability problems

Despite its in-principle commitment to private sector based approaches, UNIDO's SHP activities are biased towards community based models. None of the projects developed a private sector based user model or collaborated with micro-finance schemes, although these are considered key success factors of SHP programmes. It is widely recognized that cooperative management structures require hands-on assistance over a long period of time, a service that UNIDO has difficulties to deliver. There is no evaluation evidence that the cooperative structures set up by UNIDO at the various SHP sites could be considered as stable and sustainable.

Significant South-South potential of SHP

SHP has significant potential for South-South technology transfer. The International Centre for Small Hydro Power in China (IC-SHP) was set up in view of this strategic dimension. However, there is no evaluation evidence that, beyond donating a number of turbine-generator sets, the IC-SHP centre has made significant contributions to know-how transfer. IC-SHP staff carried out a number of missions to target countries but their assessments of site potentials in Mali and Tanzania turned out to be unreliable and their contributions to feasibility studies limited. By contrast, the South-South approach to technology transfer adopted under the Rwanda project produced more promising results. In Rwanda, UNIDO subcontracted a consultancy company from Sri Lanka for "learning by doing" and turnkey construction of three SHP demonstration plants. After this pilot phase, the Government of Rwanda contracted the same contractor from Sri Lanka directly for the construction of eight additional sites. This success story demonstrates a typical strength of UNIDO as a Specialized UN Agency.

UNIDO's added value could be strengthened

Most pilot projects were launched with UNIDO "seed money" of 100,000 to 300,000 USD although initially a volume of 1.2 million USD had been considered a minimum for "pilot country programmes". Instead of venturing into a large number of (underfinanced) pilot sites, UNIDO could have demonstrated its specific added value as a Specialized UN Agency more convincingly by concentrating on strategic studies and advice. Government officials interviewed by the reviewers expected this kind of more strategic contributions from UNIDO, such as the systematic mapping, assessment and matching of renewable energy resources and energy needs and advice for developing renewable energy strategies or building the capacity of newly created National Energy Agencies (Rwanda).

This review leads to the following main recommendations:

- Many of the country projects are at risk and should be urgently dealt with
- No more technology supply driven ad-hoc projects should be launched
- An inter-branch taskforce on “productive use” should be established
- A UNIDO strategy for “renewable and rural energy” should be prepared

1

Introduction

In May 2008 the Director General of UNIDO requested an independent evaluation of UNIDO's activities in the area of Small-scale Hydropower (SHP). This evaluation would be carried out by the UNIDO Evaluation Group (OSL/EVA) in cooperation with the "Rural and Renewable Energy" Unit (PTC/RRE) and in keeping with the UNIDO Evaluation Policy.

In June 2008, EVA and PTC/RRE agreed that, in line with the UNIDO TC Guidelines, PTC/RRE staff would carry out self-evaluations for each site in preparation for the subsequent independent evaluation. This exercise produced some useful information, although, for the majority of the projects and sites, the available information is still incomplete. Project progress reports are not available for most of the projects and there seems to be no established reporting system in PTC/RRE to which Project Managers would have to abide. As shown in table 2.1, self-evaluation reports only exist for 10 of the 24 sites. Only five self-evaluation reports are relatively complete; for nine sites the self-evaluation reports are incomplete.

The evaluation had not been included in the 2008/2009 work program of EVA. Because the SHP program is quite vast and includes 24 sites in 14 countries as well as an international centre in China and two regional centers in India and Nigeria, it was not possible to carry out a fully fledged independent evaluation within the given budgetary and resource framework. It was decided instead to carry out an independent review by EVA staff of operational sites and not to include the three SHP centers at this stage.

This review report has been prepared by Peter Loewe, UNIDO Senior Evaluation Officer. It is based on discussions at Head Quarters, progress and self-evaluation reports (wherever available) and on visits to the following sites:

- Mali (one site; by Peter Loewe, in September 2007, as part of independent review of the IP Mali)
- Ghana (one site; by Johannes Dobinger, UNIDO Evaluation Expert, in November 2007, as part of independent evaluation of the IP Ghana)
- Indonesia (one site; by Frank Pool, Independent SHP consultant, in May 2008, as part of independent evaluation of CSF Indonesia)
- Tanzania (two sites; by Peter Loewe, in September 2008)
- Rwanda (four sites; by Peter Loewe, in September 2008)
- Kenya (four sites; by Peter Loewe, in September 2008)
- Sri Lanka (one site; by Peter Loewe, in December 2008)
- The site of Mankulam in India (Kerala) could not be visited due to lack of funding. However, the regional Hydropower Centre in Trivandrum delivered a detailed self-evaluation report, which was discussed over the phone

Table 2.1 below presents an overview of the operational status of all 24 project sites.

The chapters on Indonesia and Mali are extracted (without changes) from the previously published respective evaluation reports that underwent the standard validation process for UNIDO evaluations, as laid down in the UNIDO Evaluation Policy.

Due to the weaknesses of progress reports, the review could not build on detailed figures on use of resources and cost. There are also considerable information gaps with regard to the national SHP policies and programmes in host countries, user surveys, hydropower resource assessments, technical descriptions of the installations and analysis of construction and running costs.

The reviewer and author of this report made an attempt to fill some of these information gaps by his own data gathering and research. Because SHP cannot be assessed in isolation, an attempt has also been made to shed some light on the broader picture and current trends of the overarching issues of rural electrification, energy for productive use and energy access for the poor.

Despite the information gaps and although the evaluation does not fully comply with the evaluation standards for independent evaluations laid down in the UNIDO Evaluation Policy, the evidence base is sufficiently robust for drawing general conclusions and making recommendations for the way ahead.

Taking into account the given budget and time constraints, the decision for an independent review instead of a fully-fledged independent evaluation has been the best possible compromise with a view to responding to the sense of urgency that was behind the Director General's ad-hoc evaluation request.

The reviewer trusts that the information and assessments in this report will provide the UNIDO management with the analytical and evaluative basis for urgent strategic decisions that need to be made on the future orientation of UNIDO's "Rural and Renewable Energy" activities.

The reviewer expresses his gratitude to all colleagues and stakeholders, who spent precious time for interviews and responding to information requests.

2

Summary information on sites visited

The UNIDO SHP programme covers 24 sites in 14 countries. Table 2.1 provides an overview of the operational and evaluation status of all sites:

Table 2.1: Overview of project sites

Country	#	Name of site[1]	Capacity	Status	SER[2]	Evaluation
Rwanda	1	Nyamyotsi I	75-100 kW	Operating	b	EVA staff missions
Kenya	2	Kibae	2 x 1 kW		b	
	3	Ikinu	1 kW		b	
	4	Boito	2 x 1 kW		b	
Indonesia	5	Nias Island	40 kW		none	Expert mission
India	6	Mankulam	110 kW	Operation suspended	a	None
Nigeria	7	Enugu	30 kW	Finished but problems	a	None
	8	Waya Dam	2 x 75 kW		a	
Kenya	9	Mathioya	1 kW		b	EVA staff missions
Tanzania	10	Kinko	10 kW		none	
Nigeria	11	Taraba	2 x 200 kW	Under construction	a	None
Rwanda	12	Nyamyotsi II	100 kW		b	EVA staff missions
Rwanda	13	Mutubo	200 kW		b	
Rwanda	14	Gatubwe	200 kW		b	
Mali	15	Sirakorobougou	3 kW	Construction suspended	none	
Sri Lanka	16	Meemure	40 kW	Equipment delivered but not installed	b	
Tanzania	17	Yokoma	75 kW		none	
Ghana	18	Tsatsadu-Volta	30 kW		none	
Uganda	19	River Ndugutu	250 kW		none	
Cambodia	20	Kaleng/Rattanakkiri	300 kW	Construction not started yet	a	None
Uganda	21	Bwindi	50 kW	Studies underway	none	IP evaluations
Sierra Leone	22	Port Loko	1 MW		none	
Zambia	23	Shiwanigende	1 MW		none	None
Ecuador	24	Haupamala	0.5–3 MW		none	

[1] Sites dealt with in this report are shaded.
[2] Self-evaluation reports (SER): (a) relatively complete SER available; (b) incomplete SER available; none: no SER available.

Table 2.1 indicates the status of the visited sites at the time of the review.

Mali:

In May 2007, UNIDO installed a 3 kW SHP plant in the village of Sirakorobougou, equipped with a donated turbine-generator sent from China. The Government of Mali was reluctant to finance the civil engineering part of the project because, initially, a much higher electrical power had been envisaged. Eventually, the plant was built by a local construction firm with Government funding and under supervision of a UNIDO consultant from India. However, without sufficient measurement of hydraulic resources; without a feasibility study; without an assessment of the SHP replication potential in Mali (which seems to be limited), and without an active involvement of the local population. No detailed information is available on construction cost. In July 2007, the plant was inundated and damaged by heavy rainfalls. Due to a number of technical design problems, the plant is not yet commissioned and is not operating. An independent review report of December 2007 made a number of recommendations but it is not clear whether these were followed up. To satisfy expectations of the local population, the Ministry of Energy has set up a diesel-powered mini-grid and expects UNIDO to connect the SHP to this grid. The adaptation and testing of the plant by UNIDO is pending since July 2008 despite repeated reminders from the Ministry of Energy.

Indonesia:

In April 2008 UNIDO installed a 40 kW plant on the island of Nias. The operation has been financed from post-crisis funds that became available because the island was affected by the Tsunami in 2004 and an earthquake in 2005. The initial project duration of one year was not realistic and extended by two years. Setting up a SHP plant is a medium- to long-term endeavor and the rationale of such a project as part of a post-crisis intervention is not clear. The evaluator expressed reservations with regard to the installed capacity, because no adequate measurements of the hydraulic resources are available. The plant is designed for 200 households and the total project cost has been 540.000 euro. A significant amount of these funds went into the construction of two village ICT centers in other parts of the island that are not connected to the SHP plant. None of the centers seems to be in use and the evaluator challenged the relevance of setting up ICT centers in a post-crisis environment. At the moment of the evaluation, the SHP plant was lying idle. The ownership of the plant was not clear, no management scheme was in place and the sustainability prospects of the operation were uncertain. In the meantime, UNIDO released additional funds for the delivery of income-generation equipment (mill, sewing machines, etc). The project should probably have started by initiating such income generating activities.

Tanzania:

In Tanzania, UNIDO pursued SHP related activities between 2004 and 2006. Equipment for a 75 kW SHP plant was donated by China but not installed because the site identified by the experts from China turned out to be inappropriate. Since 2005, the national electricity utility company TANESCO has carried out a number of SHP identification studies but could not yet identify an appropriate site for installing the 75 kW turbine generator set.

In 2006 UNIDO set up a 9 kW demonstration plant in the village of Kinko. Initially, the potential of this site was considered too limited and other priorities of the village (drinking water, health post) were found more pressing than lighting. However, the site was eventually retained because the estimated cost matched the available but limited UNIDO funding. The plant was designed by an expert from India who also supervised the construction, together with an expert from a NGO based in Dar-es-Salaam (440 km from Kinko). The plant has been equipped with a pump from India that is used in reverse-pump mode and other equipment from India. No detailed records of construction costs are available.

Due to the limited capacity of the site and dispersed settling mode, only a fraction of the population (100 of 800 houses) could be connected. The initial idea of providing electricity to the more remote households by solar home systems or rechargeable lamps was not put into practice nor was the "productive use" objective pursued. Instead, a community ICT centre was set up in the village school but the internet access was cut after 12 months because no funds were available to pay for connection fees.

The Mayor and the Head Teacher of the village were given informal management responsibility for the plant but no formal management scheme was put in place. It seems that the plant was operating for a couple of months in 2007 but no records of operating hours or fees collected are available. Initial warnings by TANESCO experts turned out to be realistic. During the dry season, water resources are insufficient due to competing for use of irrigation. In May 2008, the generator was damaged due to a civil design flaw (no proper flushing valves), leading to silting and maintenance problems. In July 2008, the generator was repaired through an ad-hoc intervention of the NGO expert with financial support from the UNIDO office. However, in the absence of a management scheme and because there is no collection of electricity fees, the prospects for a sustainable operation of the Kinko plant are minimal.

<u>Kenya:</u>

UNIDO's SHP project in Kenya has been built around the "energy kiosk" concept. This innovative concept replaces the traditional village mini-grid (which is an expensive solution in those cases where only lighting is required) with renewable energy based recharging of LED lamps and other batteries. In some cases, a community ICT centre with one or two computers is connected to the kiosk. The "energy kiosk" concept has the potential to make use of even minimal renewable energy power for providing scattered poor households with minimal lighting services. However, because of their very limited power of 1 to 2 kW only, the "energy kiosks" in Kenya do not allow for significant productive use of electricity.
With a UNIDO budget of 180.000 USD the SHP project in Kenya planned to set up 10 energy kiosks in the Mount Kenya region that should have been equipped with 10 donated 1 kW pico-hydro turbines from China. The implementation of the project was affected by the post-election crisis of 2007/2008 leading to delays and other inefficiencies. To date, four energy kiosks are operational, two of them equipped with computers and one of them with a small 1 kW poultry food mill, an

egg incubator and a mixer. A group of national experts contracted by the UNIDO office supervises the four “energy kiosks”, which are all operated under community-based user models. Reliable data on the cost/benefit structure of “energy kiosks” are not yet available and the typical management problems of cooperative user models remain to be solved, in particular when it comes to the “productive use”. The 2 million USD project of the multinational company OSRAM on the Lake Victoria uses also rechargeable lamps for minimal lighting but has adopted a commercial user model from which UNIDO could possibly learn.

Sri Lanka:

Sri Lanka is a country with rich experience in the promotion of SHP village schemes. There are about 300 such schemes in Central and Southern Sri Lanka. In about 150 micro-hydro powered villages, about 6,000 households are organized in the national Federation of Electricity Consumer Societies. Since 1997, the Ministry of Energy implements the “Renewable Energy for Rural Development” (RERED) programme. Under World Bank funding, more than 90 million USD connect 6,000 households to more than 100 micro-hydro village schemes with a total power of 1,432 kW. RERED cooperates intensively with national SHP promoters and manufacturers. 90% of the sites are equipped with turbines from national production. RERED has also set up a specific line of action for the promotion of the productive use of village electricity, although with rather moderate success.

When launching its SHP activities in 2005, UNIDO decided not to join efforts with RERED on the “productive use” aspect, but to use the available 300.000 USD funding from India and Austria for additional village schemes, to be powered by hybrid renewable energy equipment. For the first of these sites, the parallel use of a donated turbine-generator set from China and a biomass gasifier (DENDRO) purchased from India were envisaged. However, 12 months of delay occurred because of import taxation problems. The identification of a village site that would be appropriate for the installation of the predetermined hybrid equipment turned out to be difficult and took another couple of months. Eventually, a village in the buffer zone between a natural reserve and a national park was identified. However, to date, UNIDO has not obtained the authorization for installing the hydropower equipment in this zone. In the meantime, the planned duration of the project has more than doubled. More than half of the available budget has been spent and none of the five planned village schemes installed. Because of its quite advanced national SHP programme and the large number of existing SHP villages, Sri Lanka would have been the ideal candidate for a UNIDO initiative for the promotion of the productive use of village hydro-electricity.

Rwanda:

In Rwanda, UNIDO was quite successful in initiating a major South-South transfer of SHP technology. The operation went through three stages:
(1) construction of a 75 kW pilot plant and a mini-grid by a SHP consulting firm from Sri Lanka under a UNIDO subcontract and UNIDO funding; (2) construction of three additional plants (100 kW – 200 kW) by the same consulting firm under a UNIDO subcontract but with funding from the Rwanda Government; (3) direct

contract between the Government of Rwanda and the Sri Lankan company covering the construction of eight additional sites (400 kW – 2500 kW).

Despite some technical problems, mainly due to weak feasibility studies and inappropriate supervision of the constructions, this operation has been highly successful. Although sustainable user models and the productive use of electricity remain to be developed, the prospects for long-term sustainability are rather good because of high ownership and energetic management by the Ministry of Energy. Moreover, other donors have embarked on SHP promotion in the meantime.

The Rwanda operation has many elements of a good practice case, although with a number of caveats. In particular, the Government is not satisfied with the reporting and analytical aspects of UNIDO's contribution. The Government has asked for information about construction and operation costs at the pilot sites, which is of strategic importance for further developing the national hydropower development and electrification plans but, to date, no such information has been made available yet.

The government also regrets that UNIDO has not yet been able to make a significant contribution to strategy development. These reporting and analytical problems need to be overcome in order to safeguard the positive South-South cooperation aspects of this operation. There is an opportunity for UNIDO to support the Ministry of Energy with building the capacity of the recently set up National Energy Agency.

Ghana:

The 30 kW turbine set donated by China for the Tsatsadu site is still in a warehouse. The initial project plan failed to take into account certain social, institutional and environmental constraints and had to be revised. In spite of the limited size of the project, the Environmental Protection Agency insisted on an ex-ante Environmental Impact Assessment. Reportedly, the government is reluctant to release the estimated civil engineering investment of 300.000 USD.

India:

Under this UNIDO project, the village of Mankulam has been equipped with a 110 kW turbine and a mini-grid. However, the operation of this plant had to be suspended because the available electrical power was not sufficient to provide electricity to all households of Mankulam. To meet the growing electricity demand, the Government decided to extend the central grid, which was already nearby, by another 7 km. There is a possibility to connect the SHP plant could be connected to the grid but this would require technical modifications and net-metering agreements with the electricity utility that are currently under discussion.

3

The planning basis of the UNIDO SHP promotion activities

The SHP activities analyzed by this review were implemented by the *Renewable and Rural Energy Unit* under the *Energy and Climate Change Branch* and come under UNIDO's thematic priority *Energy and Environment.*

The programmatic and planning basis of these SHP activities was rather weak. No programmatic document could be identified that provides the analytical basis or detailed plans for a SHP programme. The only programmatic document that could be identified is the draft paper *"UNIDO Initiative on Rural Energy for Productive Use"* dating back to June 2002. [3] However, this paper does not focus specifically on SHP.

The paper *"UNIDO Initiative on Rural Energy for Productive Use"* defines the target group of the initiative as *"those parts of the population of developing countries that are either too poor, or too isolated to attract private sector energy-related investments."* The paper explains in broad terms that *"UNIDO promotes the productive (income generating) uses of energy for rural development (industrialization) and poverty alleviation. In addition, UNIDO's energy programmes cover capacity building activities related to renewable energy technology and the assembly and manufacture of energy equipment and structures in developing countries."*

Furthermore, the paper claims that *"Technology options are known and well-explored. Therefore, the real challenge is the "packaging" of rural energy programmes, that is, combining components such as capacity building, technology transfer, training, financing, costing, increasing the income level of rural people, maintaining and repairing, etc."*

With regard to productive energy use the paper emphasizes that UNIDO would *"actively promote rural entrepreneurs to establish and run rural energy businesses. The development of rural energy entrepreneurs would stimulate the economic performance of the area, contribute to the development of SMEs, and build capacity for rural development."*

The paper elaborates mostly on the "too isolated" part of the target group. With regard to providing better access to energy for the "too poor" it states that appropriate financing mechanisms leveraging private investment and *"combining ODA, grant money and loans in a judicious mix"* would be a key challenge.

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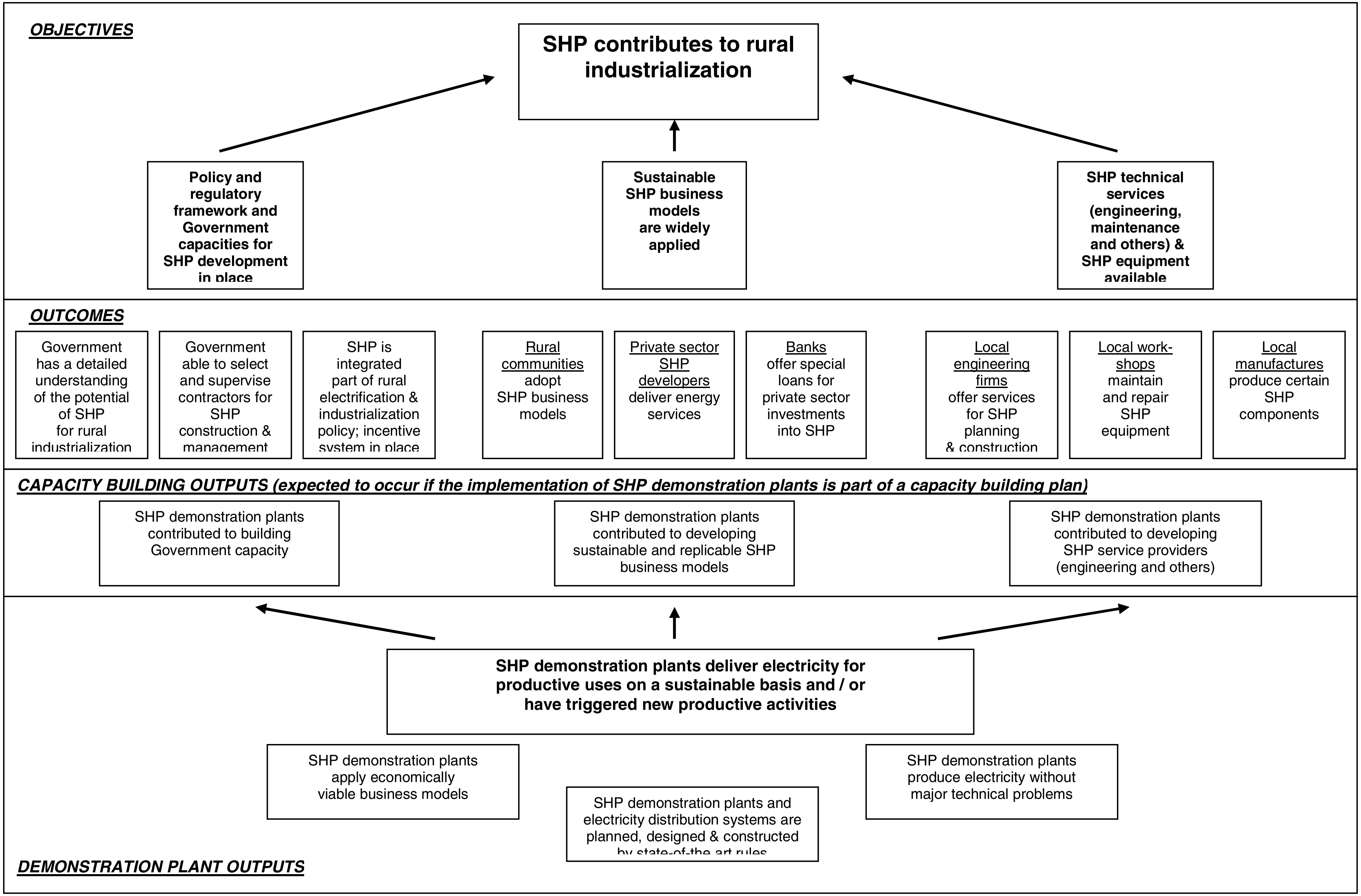
[3] The paper comprises 8 pages of text and 8 pages of annexes.

It is a shortcoming of this paper that it equates rural energy with renewable energy. No reference is made to grid electricity and possible measures to enhance access of the poorer parts of the population to the grid, which is by far the most important source of energy, also in rural areas.

In the annex of the paper it is estimated that 1.2 million USD would be an appropriate budget for "*pilot activities per country*". However, no detailed explanations are given about the nature of such country programmes.

Quite clearly, the paper described above does not provide sufficient detail to be used as a reference basis for this evaluation. As an attempt to overcome this weakness, the assumed implicit intervention logic of UNIDO's SHP activities has been tentatively reconstructed as shown in Exhibit 3.1.

Exhibit 2.1: Tentative reconstruction of a logframe for UNIDO SHP activities



4

Conclusions & recommendations

4.1. Conclusions related to strategy, relevance and effectiveness

Programmatic planning deficit

There is no evidence that UNIDO deployed adequate analytical and planning efforts to prepare its rural energy programme in general and the SHP promotion activities in particular.[4] There is also no evidence that UNIDO keeps abreast with the literature and evaluations dealing with rural electrification and SHP programmes of other donors. The SHP promotion activities have not been supported by systematic collection and analysis of data and information. This analytical, planning and monitoring deficit is reflected at all levels: at the programmatic level; at the country level by a lack of country programmes and analysis of the replication potential; and at the level of the individual SHP sites by the weakness of feasibility studies or the lack of such studies. Country studies were foreseen under some of the projects but not executed. For most of UNIDO's SHP country programmes, there is no evidence that these programmes take into account national electrification and industrialization strategies.

Key assumptions not substantiated, nor confirmed

The programme rationale seems to be founded on the assumption that SHP is a source of energy that is widely applicable across a large range of developing countries and that is characterized by a considerable potential to create triple impact on carbon emissions, poverty alleviation and industrial development. Because of the analytical and programmatic planning deficit these assumptions have not been substantiated nor are they confirmed by the findings this independent review.

SHP is constrained by natural conditions and geographical proximity

More than other renewable energy sources, SHP is constrained by specific natural conditions and by geographical proximity. The economic viability of SHP depends on the combined presence of constant water resources throughout the year (generous rainfall, thick forests) and steep hillsides (low head SHP tends to be too costly). However, in many tropical regions, water resources are subject to strong seasonal variations. In those regions with only one rainy peak season the economic viability of SHP tends to be questionable. In Tanzania, the sites explored and developed by the programme run into difficulties precisely because water resources were limited and subject to competing uses, mainly irrigation. In Kenya and Sri Lanka, the project had to envisage hybrid solutions (solar and

[4] The only programmatic document that could be identified is the briefing paper of 8 pages *"UNIDO Initiative on Rural Energy for Productive Use"*, which dates back to June 2002.

biomass gasification in addition to SHP) in order to bridge limited hydropower resources during the dry season. While such hybrid solutions are technically possible, they tend to be complicated and costly in most cases.

Furthermore, the exploitation of SHP is constrained by geographical proximity: A potential SHP site that is located more than a few kilometers from the point of energy use (village or production facility) are not economically viable because of prohibitive electricity transmission costs. The UNIDO SHP programme underestimated these natural and geographical constraints. Moreover, for none of the pilot sites developed under the SHP programme, the replication potential has been demonstrated.

Under several country projects, the systematic mapping and measurement of hydropower resources was planned but in none of the visited countries such analysis took place.[5] On a global scale, UNIDO tends to assess the potential of SHP very optimistically but the basis for such assessments remains unclear because UNIDO did not yet carry out any systematic assessment of the *economically viable* SHP resources world wide.

"Productive use" does not develop spontaneously

Industrial development is at the core of the UNIDO mandate. However, in practice, UNIDO seems to be focusing on rural lighting, which is more of a social or rural development issue. The rationale of UNIDO's involvement in SHP development is built on the assumption that SHP development triggers industrial development. The independent review did not produce evidence that this assumption is realistic. At none of the pilot sites was there a significant degree of "productive use" observed. The observation is in line with the scientific literature and all major evaluations of rural electrification programmes. It is widely recognized that electricity by itself does not lead to industrial development. Other factors than the mere availability and price of electricity are influencing the decisions of the population to engage in productive activities. It is, therefore, widely accepted that electrification programmes, whether renewable energy based or not, require a package of dedicated activities for the promotion of "productive use". There is no evidence that UNIDO has given sufficient attention to the longstanding debate of these issues. In the cases of the Tanzania and Kenya projects, the potential of SHP to generate "productive use" is further constrained by power limitations. It is in fact, unlikely that the limited power of pico- and micro-hydro plants is sufficient for significant productive use.

The "anti-poor pattern" of rural electrification

In many countries rural electrification is of high priority and the national central grid is rapidly advancing into rural areas. However, the advancement of the grid to rural areas does not automatically lead to better access to electricity for the poor. Millions of poor people living nearby the grid cannot afford grid connection. Many evaluations emphasize the "anti-poor pattern" of rural electrification programmes. In principle, these considerations apply also to SHP based

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[5] It seems that a regional potential study and a detailed feasibility study have been prepared for Ecuador but none of these studies or a self-evaluation report for this country has been made available.

electrification schemes. Setting up village electrification schemes does not solve the problem because, even if the *poverty rate* in remote areas may be high, the *poverty density* is much higher in densely populated urban or peri-urban areas. Therefore, bringing electricity to remote places may be a priority of the local elite but does not necessarily mean bringing electricity to the poor. The most effective way of bringing electricity to a large number of poor people would be subsidizing their access to the grid. However, as already pointed out, providing the poor with access to electricity for lighting purposes is not a core part of UNIDO's mandate.

Village electricity and carbon reduction are competing objectives

Hydroelectricity has a high potential for substituting fossil energy by renewable energy. However, the smaller a hydropower plant, the smaller its contribution to reducing carbon emissions. One single SHP plant of 1 MW saves the same emissions as 1000 pico-hydro plants of 1 kW. In order to be effective, an SHP project that aims to reduce carbon emissions should promote grid connected bigger SHPs and not very small off-grid village schemes because grid connected SHPs make more efficient use of the available hydrological resources. The World Bank financed programme for "Renewable Energy for Rural Economic Development" in Sri Lanka is a case in point. The SHP part of this successful programme has two different arms: Off-grid micro-hydro plants for village electricity and grid-based small hydro plants for carbon reduction. One of the underlying assumptions of the UNIDO SHP programme is therefore not realistic: Off-grid electricity for isolated villages and significant carbon reduction are two different objectives that cannot be pursued effectively by the same means.

Significant South-South potential of SHP

SHP is a thematic area with significant potential for South-South technology transfer. UNIDO's International Centre for Small Hydro Power in China (IC-SHP) and two regional SHP centres in India and Nigeria were set up to take care of this strategic dimension. However, there is no evidence that, beyond donating a number of turbine-generator sets, the IC-SHP centre has made significant contributions to knowledge transfer. IC-SHP staff carried out a number of missions to target countries but their assessments of site potentials in Mali and Tanzania turned out to be unreliable and their contributions to feasibility studies limited. There seems to be a tendency of limiting South-South technology transfer to delivering hardware and organizing conferences, which is inadequate. The South-South technology transfer approach adopted under the project in Rwanda is more promising. There, UNIDO subcontracted a consultancy company from Sri Lanka for "learning by doing" and turnkey construction of three SHP demonstration plants. However, the attempt of transferring the user model of "Village Electricity Consumer Societies" from Sri Lanka to Rwanda failed.

4.2. Conclusions related to programme execution and efficiency

Technology supply driven approach

The briefing paper of 2002 on rural energy for productive use specified that technology options are known and well-explored and that, therefore, the real challenge is the "packaging" of complementary activities related to technology transfer, capacity building, training, micro-finance, income creation, etc. However, in practice, such packaging did not take place. Moreover, the programme relied to a large extent on the installation of donated turbines from China leading, in many cases, to a technology supply driven approach. In four countries, Chinese turbines were delivered but are not yet installed. Sri Lanka has been an extreme case, where the decision of importing a donated turbine instead of using a nationally manufactured turbine delayed the project by more than a year, caused significant additional cost and was counterproductive in terms of supporting the local manufacturing capacity. It should be noted that the turbine cost is, in most cases, insignificant as compared to the overall project cost.

Weak feasibility studies

The weakness of project feasibility studies or, sometimes, the lack of such studies had negative consequences on project quality and efficiency. The availability of hydropower resources throughout the year and other critical technical parameters such as silt load were not properly assessed. This shortcoming led to costly corrections of design during project execution, maintenance problems and seemingly to under-equipping certain sites. It is also striking that feasibility studies did not consider the extension of the central grid that has reached several sites during the execution of the project or soon after its finalization. Grid connection needs to be built into the design, in order to avoid additional cost or closing down of SHP plants. At none of the sites, electricity production costs were properly estimated in ex-ante feasibility studies or calculated ex-post by “as-is studies”.

Hidden subsidies

Although not clearly spelled out, UNIDO has adopted a policy of installing SHP plants for free, not accounting for investment costs and, hence, setting electricity tariffs below cost. This decision of applying hidden subsidies seems to be partly unconscious, due to the deficient collection of economic data and analysis of cost structures. Even if there may be a case for bringing down electricity tariffs by subsidies for the poor, such subsidies should be targeted, transparent, effective, sustainable and rooted in political priority setting. In practice, the hidden subsidies applied by UNIDO jeopardize government attempts to develop, in parallel to the UNIDO experience, commercially viable and private sector based user models under other renewable schemes financed by other donors.

Bias towards community based user models

Despite the plea for private sector based approaches in the 2002 briefing paper, the implementation of the SHP programme is characterized by a strong bias towards cooperative and community based models. The de-facto focus on village electricity consumer associations entailed considerable management and sustainability problems. At all visited sites, the collection of electricity fees proved difficult, leading to significant deficits. In most cases, the challenges and cost of maintenance were higher than expected. None of the projects made an attempt to develop a private sector based user model or to collaborate with micro-finance schemes, although this is widely recognized as a key challenge of SHP programmes and had also been envisaged in the early days of the programme. The problems with cooperative management structures at village level are not surprising and confirm the experience reported in scientific literature and evaluations from other organizations. It is widely recognized that cooperative management structures require hands-on assistance over a long period of time, which is a service that UNIDO cannot deliver, given the specificities of its delivery mode. There is no evaluation evidence that the cooperative structures set up by UNIDO for running SHP schemes could be considered as stable and sustainable.

<u>Limitations of the UNIDO TC delivery mode</u>

The transfer of SHP technology requires the longer term presence of experts, not only during construction but in particular for capacity building and developing sustainable user structures, once the SHP plant is technically functioning. Long-term follow-up by partner structures (Government; utilities or local NGOs) is therefore crucial. All visited SHP projects experienced problems in this respect. In Kenya, the UNIDO office contracted a group of national experts to accompany the various pilot sites but this solution was not embedded in national structures and therefore not sustainable. In Tanzania, no assistance was provided after inauguration of the pilot plant in Kinko except some ad-hoc fire-brigading from the UNIDO office and the operation failed because of management problems. In Mali, major problems and design weaknesses occurred already during construction, because of insufficient expertise.

In Rwanda, UNIDO's standard delivery mode was replaced by a turn-key arrangement with a subcontractor from Sri Lanka, who was also expected to take care of post-construction issues. This turn-key arrangement seems to have worked for construction, despite certain technical design problems that could have been avoided with a more state-of-the-art approach to supervising the turn-key contractor.

At all sites UNIDO failed to mobilize inter-disciplinary know-how from HQ, which could have been a potential strength of its delivery. Such "packaging" of services was initially foreseen but did not materialize in practice. UNIDO services other than the "Rural and renewable energy unit" did not participate in implementation.

<u>UNIDO's added value could be strengthened</u>

The limitation of UNIDO's TC delivery mode raises also the question of strengthening the genuine added value that the Organization could bring to SHP projects. A major achievement in this respect has been the successful South-South transfer of SHP technology from Sri Lanka to Rwanda. This success story demonstrates the typical strength of a UN agency and it is unlikely that a bi-lateral development agency would have adopted the same approach. After the pilot phase with UNIDO, the Government of Rwanda contracted the turn-key contractor from Sri Lanka directly but there is still room for UNIDO to pursue its South-South approach with other companies from Sri Lanka, for building maintenance and eventually even productive capacities for SHP turbines in Rwanda.

More often than not, there seems to be a typical UNIDO penchant for "pilot projects" and "jump starting". The rationale for UNIDO pilot projects at remote sites without the necessary integration in national structures is even more questionable because, in most cases the available funding has been extremely limited. Although the 2002 briefing paper had explicitly envisaged a volume of 1.2 million USD for “pilot country programmes”, most of these programmes were launched with UNIDO “seed money” of 100,000 to 300,000 USD leading to implementation and sustainability problems and, at least in some cases, to negative demonstration effects.

Arguably, UNIDO could have demonstrated its specific added value as an international organization more convincingly by concentrating the limited amount of its “seed money” to strategic studies and advice. Government officials interviewed by the evaluators expected more strategic contributions from UNIDO, such as the systematic mapping, assessment and matching of renewable energy resources and energy needs and advice for developing renewable energy strategies. Several missed opportunities of such kind could be cited, such as the hydro-atlas for Rwanda produced by the Belgian cooperation or the GTZ identification study of SHP sites in Kenya. In Rwanda, a National Energy Agency is currently being created but there is no sign that UNIDO is offering its contribution for building the capacity of this new key player.

Weak reporting, accountability and learning mechanisms

The execution of the SHP programme has been characterized by weaknesses in reporting, accountability and systematic learning. Regular project progress reports are not available. Self-evaluation reports are deficient (only 5 SERs are relatively complete; 9 are incomplete; 10 are lacking – see table 2.1). The results of “pilot projects” are not analyzed in a systematic manner and no explicit lessons are drawn from the projects. The delivery of outputs and deliverables mentioned in project documents is not verified, and underperformance of consultants and national experts are not sanctioned, and recommendations from evaluations are not followed through. There is no evidence for systematic learning at unit level or transfer of experiences between individual project officers.

4.3. Contributions to objectives of the “Renewable and rural energy unit”

In line with the principles of “Results Based Management” UNIDO projects are supposed to contribute to the objectives of the organizational units.

There is no evidence that the SHP promotion activities made significant contributions to the objectives of the “Renewable and rural energy unit” that are defined as follows in the “Terms of Reference for the Organizational Units of UNIDO”[6] :

> *“The Unit is responsible for enhancing greater use by industry of renewable sources of energy and facilitating the access of the poor in rural areas to affordable and sustainable energy to generate off-farm income and employment opportunities”*

No *use by industry of renewable energy sources* and virtually no *off-farm income and employment opportunities* have been generated.

[6] Annex II of the DG Bulletin dated 29 February 2008

The contributions of the SHP activities to the nine functions of the unit as described by the Terms of Reference are rated below:

	Description of unit functions	Assessment
1	Strengthen the capacity of public and private-sector support institutions to assist SMEs meet their energy demands with renewable sources of energy.	No contribution Energy needs of SMEs were not considered
2	Promote the transfer of appropriate renewable energy technologies for use by SMEs.	
3	Wherever possible, strengthen the capacity of local enterprises to undertake the manufacture, assembly, repair and maintenance of renewable-energy equipment.	No contribution
4	Strengthen institutional capacities for the formulation and implementation of industrial renewable energy projects capable of securing carbon crediting under the Clean Development Mechanism, through Joint Implementation, and under the Greenhouse Gas (GHG) Emissions Trading Scheme of the European Union.	No contribution
5	Prepare energy needs assessments focusing on the requirements of poor segments of the population living in remote areas and having no access to modern energy services.	No significant contribution
6	Assist counterparts to carry out market surveys identifying (potential) energy users and income-generating productive activities.	No significant contribution
7	Strengthen the capacities of counterparts to select energy generating technologies, giving priority where economically viable to renewable-energy-based technologies, and to demonstrate the social and economic viability of the selected technologies.	No significant contribution Similar analysis foreseen by some of the projects but mostly not executed
8	Strengthen the capacity of counterparts to support local entrepreneurs to create sustainable local enterprises that can deliver reliable energy services based on the chosen energy technologies.	No significant contribution projects focused on community based approaches
9	Actively participate in, and collaborate with, global fora focusing on renewable energy, including the Global Environment Facility, UN-Energy, the Global Bioenergy Partnership, and the UNFCCC.	No significant contribution No publications or similar products available

4.4. Recommendations

Strengthen the “Renewable and rural energy unit”

Establish rigorous planning reporting and accountability mechanisms at the RRE unit. Exercise team building and encourage the exchange of experience and learning between the members of the RRE unit and with the other units of the Energy branch, in particular with the Energy Policy and Partnership unit.

Deal with projects at risk

There is a considerable amount of weaknesses and risks in the SHP programme portfolio, such as: equipment delivered but dormant in warehouses; Government requests not responded to; projects dragging on without action; non-functioning SHP schemes left behind closed projects; etc. The RRE unit should screen the portfolio of SHP projects for risks, set priorities and deal systematically with projects at risk. A peer review of the portfolio involving all project officers of RRE may worth trying as an appropriate mechanism.

Avoid ad-hoc projects

UNIDO should avoid launching major new RRE projects on an ad-hoc basis without taking stock of the experience made over the last seven years and without a solid strategy for “renewable and rural energy” that should be shared and owned not only by the RRE unit but also by the relevant other parts of the Organization.

Establish an inter-branch taskforce on RRE

Promoting the use of *“renewable and rural energy”* for productive purposes is not primarily an energy issue but an issue of rural business development. In UNIDO, the know-how for rural business development is concentrated in the PSD and AGRO branches. These branches should not only be associated but take the lead when it comes to promoting the productive use of rural electricity on the ground. An inter-branch taskforce on RRE should be established, where strategic decisions are made and responsibilities for projects and project components attributed.

Prepare a UNIDO strategy for “renewable and rural energy”

Promoting Small-scale Hydro Power as a specific line of action is a technology supply driven approach and should be abandoned. Instead, UNIDO should develop a comprehensive and well founded strategy for the promotion of “rural energy for productive use”.

This strategy should be demand driven and not limited to one particular source of energy or to renewable energies. Instead, the strategy should start from analyzing productive energy needs in rural areas and not be limited to off-grid solutions, but take into account the conventional rural electrification efforts that are widespread in many countries.

The strategy should not focus on electric lighting or other household appliances but adhere to UNIDO's core mandate of promoting economic and industrial development. Accompanying IFI-financed rural electrification programmes with a "productive use" component could be an attractive new TC product for UNIDO to be included in the Programme.

It is unlikely that the triple objective of poverty alleviation, industrial development and reducing carbon emissions through renewable energies can be reached by the same type of intervention. The "rural energy for productive use" strategy should, therefore, develop a toolbox comprising different types of interventions for different objectives and different natural, economic and political environments.

The strategy should encompass not only traditional TC but also address CSR opportunities of collaboration with multinationals seeking to develop "bottom billion" products and markets; normative issues such as new norms and standards for more low-cost approaches to rural electrification; "Global Forum" activities; and policy advice.

The strategy should build on UNIDO's own successful experience in Rwanda with initiating South-South cooperation and technology transfer and also take into account relevant experience and good practice of other donors such as the RERED programme in Sri Lanka.
Most importantly, UNIDO should move away from "pilot projects" but rather develop a methodology for policy advice to governments on rural and renewable energy issues, including practical tools for priority setting and decision making.

5

Rural electrification: Some basic facts and trends

There is a basic assumption that Small-scale Hydropower (SHP) promotional programmes such as the one under review, that SHP is a promising source of Renewable Energy with widespread geographical applicability and a strong potential for poverty reduction and job creation in rural areas.

An exhaustive analysis of this assumption is beyond the scope of this review. However, SHP based electrification being only one alternative among others to conventional grid based electrification; and is necessary to consider some basic facts and trends in rural electrification. Assessing the relevance and effectiveness of SHP solutions would not be possible without a basic understanding of rural electrification in the larger sense.

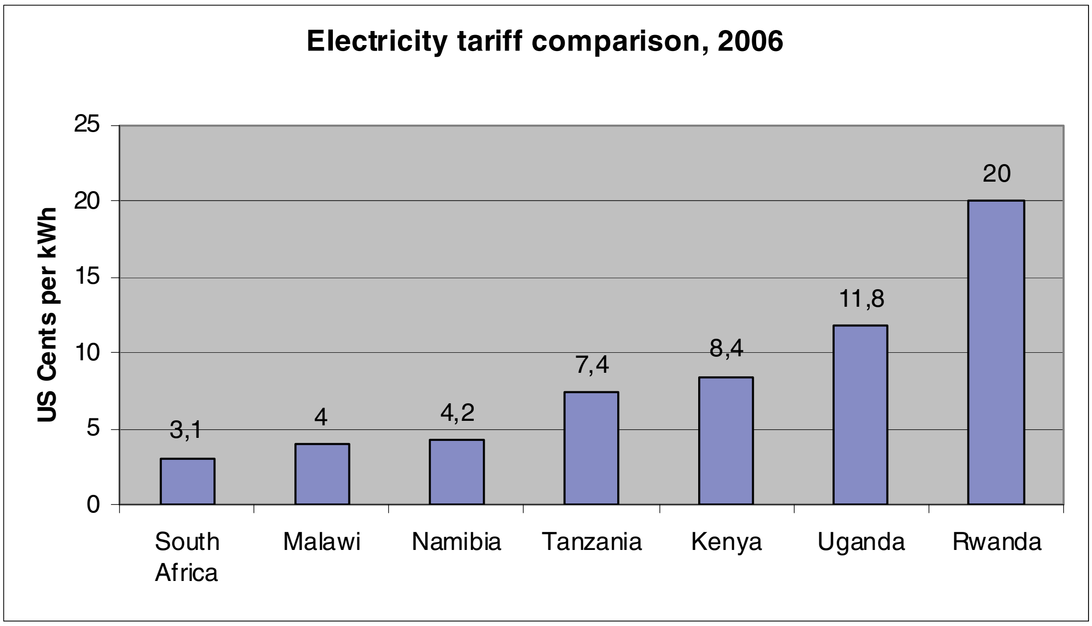
5.1. Rural electrification: policies, costs, benefits

Over many decades and under the most diverse historical and political circumstances the extension of the electricity grid to rural areas has been considered as one of the most powerful drivers of development. All developing countries see electrification as a necessary condition on their way out of poverty. Moreover, rural electrification is often perceived as an indispensable precondition for industrialization. Hence the high political priority and the considerable financial means dedicated to rural electrification programmes.

The geographical coverage and tariffs applied under a central grid are key parameters that affect the relevance and effectiveness of any SHP project.

As an illustration, Exhibit 5.1 shows the wide variations of national electricity tariffs in East and Southern Africa. The reasons for such variations can be manifold and relate to the cost structures of electricity generation and distribution as well as to pricing policies.

Exhibit 5.1: Comparison of electricity tariffs in East and Southern Africa



Source: TANESCO Tariff Application 2008; Dar es Salaam; August 2007

Cost benefit analyses of rural electrification programs are rather complex. The different costs factors of energy generation, transmission and distribution should be distinguished. A World Bank evaluation of rural electrification programs analyzed the cost structure of rural electrification as follows:

> *"It costs more to provide electricity to rural than to urban communities … The higher rural investment costs - measured as capital infrastructure costs per kilowatt hour consumed - partly reflect the lower density of rural connections and the smaller amounts consumed by those connected … Investment costs per unit of demand are higher in rural areas because the bulk of demand in rural areas is for lighting during the early evening. Thus the ratio of average demand (which determines financial and economic benefits) to peak demand (which determines investment cost) is much lower in rural systems than in urban, where there is considerable daytime electricity use … Largely because rural demand is concentrated at the time of the national system's peak load, generation costs are higher for rural than for urban consumption. The cost of generating electricity to meet peak load demand is often more than double the long-run marginal cost averaged over the entire day (or year)"*[7]

Three key points should be retained from this analysis:

- Rural electrification is structurally more expensive than urban electrification
- The cost of rural electricity *distribution and transmission* is high because of low population density in rural areas

[7] Rural Electrification: a hard look at costs and benefits; World Bank OED; 1995

- The cost of rural electricity *generation* is high because of unfavorable load factors (absence of productive daytime use in rural areas and peak consumption in evening hours due to lighting)

The situation in Kenya, one of the countries covered by UNIDO's SHP program, illustrates the relative weight of transmission and dissemination costs. KPLC, the national electricity distribution utility in Kenya, buys electricity from its major supplier KENGEN at a price of about 2 US cents per kWh and sells it to the consumer at an average tariff of about 10 US cents per kWh. This ratio of almost 90% of the electricity price going into energy transmission and dissemination may be an extreme case but, by no means, rural electricity cost can be reduced to the sole costs of electricity generation.

Rural electrification is a highly political issue. An analysis of village electrification schemes in Ghana underlined the political influence that drives grid extension. *"No electrification no vote"* has been quoted in this case study as an attitude among off-grid communities. It is quite common that electorates are promised grid power (or 900 solar home systems as in the case in Ghana) in exchange for votes. Not surprisingly, this may lead to a situation where access to grid electricity is almost propagated as some kind of human right, rather than an infrastructure investment that is subject to economic considerations.

However, in many developing countries the room for political influence on electrification decisions is shrinking because governments have embarked on liberalizing national energy markets by dismantling national electricity monopolies, separating the generation, transmission and dissemination of electricity, creating national regulation bodies and, eventually, privatizing all, or parts of, their energy infrastructure.[8] TANESCO, the national electricity utility of Tanzania for instance reported in its 2007 Annual Report that…

> *"The current cost of supply to final consumers for TANESCO is Tshs 164/kWh, and the average tariff charged is around Tshs 96. This means that TANESCO loses, on average, about Tshs 68 on every kWh sold. As a consequence, the company is operating deeply "in the red."…The shortfall between our revenues and our costs has historically been covered by direct and indirect subsidies from the Government's budget, but from financial year 2007/8 the Government will not subsidize TANESCO from its budget, except Tshs 18,000 million for part payment of IPTL Capacity Charges"*

For the present review it can be concluded that the national electrification policy, tariff structures and the state of advancement of the national grid have to be taken into account when designing (and evaluating) SHP programs.

[8] This does not mean that liberalization prevents policy driven electrification. The "Electricity for All" program in South Africa is an example of a successful electrification program pursuing social objectives under the conditions of a liberalized electricity sector. See: Meeting Electrification's Social Objectives and Implications for Developing Countries; C.T Gaunt; Energy Policy (33); 2005

5.2. Overcoming the “anti-poor pattern” of rural electrification

Despite the high political priority for rural electrification and subsidized tariffs, the assumed positive impact of electrification programmes on poverty and industrialization is not self-evident.

In 2001 a SHP study[9] compared eight evaluations of major electrification programmes and drew provocative conclusions such as: *“no general conclusion that the poor benefit”*, *“low income group cannot afford despite subsidies”* and *“no benefits to poor”*. Evaluation findings about impact of electrification programmes on rural development and economic growth were also rather pessimistic ranging from *“no positive economic impact”* to “*a crucial part in rural development but only if basic economic and other preconditions exist”*.

A World Bank evaluation of rural electrification projects in 1995 confirms these general findings:

> *“All the evidence to date, including that from Bank-financed rural electrification projects in Asia, shows that rural electrification does not directly reduce poverty by helping the poorest rural people. Most of the direct benefits from rural electricity go to wealthier people. Even when tariffs are low, potential consumers cannot always afford the initial connection and household wiring. Once connected, the amount of electricity consumed, and therefore the benefits obtained, depend on the ability to buy electrical equipment, whether light fixtures, televisions, fans, water pumps, or motor-driven machines. Evidence from Indonesia suggests that the poorest 25-50 percent of the population could not afford electricity, even if connections were to be financed through power company loans”*[10]

The fact that electrification programmes have difficulties in reaching the poor does not mean that energy is not an issue for these parts of the population. On the contrary, there is clear evidence that poor people spend a higher percentage of their income on energy than non-poor people. Table 5.2 for example illustrates the situation in Tanzania where Kerosene for lighting purposes and dry cell batteries alone account for more than 20% of urban poor expenditure.

Table 5.1: Energy expenditure as percentage of urban household income

Energy type	Poor	Non-Poor
Electricity	1.7	2.5
Kerosene	17.7	5.5
Charcoal	12.4	5.4
Fuel wood	0.1	0.3
Dry cell batteries	3.3	0.8
Total	**35.2**	**14.4**

[9] Meyer, Thomas; Mini Hydropower for Rural Development; Zurich; 2001
[10] Rural Electrification: a hard look at costs and benefits; World Bank OED; 1995

Although connection to the grid has the potential of cutting down at least some of these energy expenditures, most of the poor cannot afford electricity, mainly because of high entry costs (grid connection and house wiring). This is confirmed by the situation in Kenya, Tanzania, Rwanda and other countries covered by the SHP programme under evaluation. In Kenya for instance, the house connection fee amounts to 32,500 Ksh, a figure that is 16 times higher than the poverty line in Kenya, which is about 2000 Ksh per month and household member (28% of the households fall below the poverty line, see the chapter on Kenya below)[11].

In order to properly assess the outreach of rural electrification programs to the poor the basic distinction between the *village* electrification rate and the *household* electrification rate is essential and must not be neglected. The current situation in the countries covered by the SHP program of UNIDO confirms the finding of the World Bank evaluation of 1995 that between 25% and 50% of the population of electrified villages cannot afford grid connection.

In Rwanda, for example, only 3% of the rural population has access to electricity although, over the last 10 years, the national grid expanded considerably. It is estimated that more than 50% of the population live at a distance of less than 5 km from the grid. A recent survey carried out by the "Lighting Africa" initiative of the World Bank among Kenyan households and traders confirmed that it is not proximity to the power line but cost that constitutes the main factor excluding poor people from grid connection. For 49 % of households in the sample (66% of traders) the grid is on the street they live or close by. For an additional 31% of the households (19% of the traders) the grid is within 5 kms.[12].

The above analysis contradicts the myth that bringing electricity to remote places means bringing electricity to the poor. Although the *poverty rate* (share of poor people among the population) may be higher in remote areas, the *poverty density* (number of poor people per km2) is much higher in urban and densely populated areas. Strategies aiming at better access to grid electricity for the urban poor are therefore more likely to produce significant poverty impact than village electrification projects, which are more likely to serve the rural elite.

The most recent impact evaluation of 120 electrification projects carried out by the Independent Evaluation Group of the World Bank in 2008 confirms this analysis. This evaluation diagnosed an intrinsic *"anti-poor pattern in electrification"* and confirmed the view that *"the larger share of benefits from rural electrification is captured by the non-poor"*. [13] The evaluation acknowledges that many governments pursue reaching the poor as a political objective. But it underlines that this objective cannot be reached through tariffs below cost recovery because this solution would undermine the financial sustainability of the (public or private) utilities responsible for electricity distribution.

[11] Updating of the Rural Electrification Master Plan; Socio-economic Survey and Rural Electricity Demand Analysis; Nairobi, September 2008

[12] http://lightingafrica.org

[13] The Welfare Impact of Rural Electrification: A reassessment of the Costs and Benefits; World Bank Independent Evaluation Group; 2008

The evaluation concludes that, in order for electrification programs to reach the poor, “life-line tariffs” for households using only very small amounts of electricity (typically less than 50kWh/month) are key and special credit markets should be developed to allow poor households to borrow money for the connection charge.

A number of conclusions can be drawn from this brief analysis of rural electrification programs and possible strategies to overcome their “anti-poor pattern”:

- Most of the direct benefits from rural electrification go to wealthier people
- Bringing electricity to remote places is beneficial for regional development but it does not necessarily lead to better electricity access for the poor
- A large part of poor households cannot afford grid access even if the grid is at their doorstep
- Poor households are mainly interested in electricity for lighting and radio batteries; their electricity consumption remains weak because they cannot afford other more expensive electrical equipment
- “Electricity for the poor” projects in urban regions with a high *poverty density* are likely to reach a larger number of poor people as compared to rural regions, even if the *poverty rate* in these regions may be higher
- Electricity use for *productive* activities may therefore be more beneficial for poor households than electricity access for household purposes

5.3. Community based electrification schemes

Rural electrification strategies have varied widely throughout history depending on the political and economic situation of a given country and its socio-cultural background. While many industrialized countries relied on more or less centralized state-owned electrification systems, the United States exemplifies a country where *electricity cooperatives* have been an important player in rural electrification (Box 5.1).

A number of developing countries have followed cooperative based electrification approaches or at least tried to combine centralized and decentralized elements in their electrification policy.

However, promoting development cooperatives is rarely an easy solution and electricity cooperatives do not escape from this experience. Urambo in Tanzania is a well-documented and often quoted case study (see box).

The country specific differences between China and Thailand presented in chapter 4.3 further down are also highly instructive in this respect. While community based electrification schemes seem to have been the standard solution in rural China for many decades, the same solutions have failed in Thailand. The mixed experiences with Village Electricity Consumer Societies in Sri Lanka reported in chapter 5 and in Rwanda (chapter 6) are other cases in point.

Box 5.1: The US National Rural Electric Cooperative Association (NRECA)

NRECA represents the interests more than 900 electricity cooperatives serving 39 million electricity consumers across the United States. Founded in 1942, NRECA overcame the shortages of electric construction materials brought on by World War II, helped newly-formed rural electric cooperatives obtain insurance coverage, and mitigated wholesale power problems. Since then, NRECA has advocated on behalf of consumer-owned cooperatives with regard to energy and operational issues and has promoted rural community and economic development in the US.

NRECA's international arm NRECA International, Ltd. has pioneered low cost rural electrification construction design and standards in more than 40 developing countries. It provides comprehensive training programs in all aspects of utility operations and management to ensure that local institutions can effectively and efficiently operate and administer a functioning and economically viable utility. A comprehensive series of Technical Assistance Guidebooks (TAGs) provides a combination of "best practices" and "how to" guidelines for subjects such as:

- Creating an Electric Cooperative
- Functions of the Board of Directors of ECs
- Preparation of a Business Plan for ECs
- Construction Standards for Rural Electrification
- Analysis of Productive Uses
- Project Economic Analysis

Source: http://www.nreca.org/

Scientific literature and evaluations reports offer a great deal of different experiences with community based electrification. The core message is the same: Setting up an electricity cooperative is a possible solution but the realism of this solution very much depends on the dominant local development model. Even under the best possible conditions, community based electrification is a long-term endeavor that requires the continuous presence of technical and management support over many years.

Box 5.2: The case of the Urambo Electric Consumers Co-operative Society

10% of the households in this township of 20.000 persons are electrified through a 3 x 85kW generator set that is run by an electricity cooperative. The experience started in 1992 with the transfer of the equipment to an informal electricity committee, which was supposed to collect electricity fees, and a government engineer being in charge of the operation of the generators. This system failed because of unclear obligations of the electricity users and the fact that nobody had the responsibility to ensure the long-term sustainability of the service.

In 1993, the electricity consumers formed the Urambo Electric Consumers Co-operative Society (UECCO) with the assistance of TANESCO and SIDA. The by-laws for UECCO and the technical service contract between UECCO and TANESCO were formulated with reference to guidelines from NRECA and the Swedish Electricity Association and inputs from the Legal Secretary of TANESCO. Three influential individuals from Urambo were engaged as trustees with the task to support the co-operative in legal matters.

After rehabilitation of the electricity generators with financial support from SIDA the equipment was formally transferred to cooperative ownership. Regular operation under co-operative management started in June 1994. During eight (!) years - between 1994 and 2002 - the co-operative was accompanied continuously by TANESCO and SIDA. During this period the co-operative consolidated steadily with the number of members increasing from 67 to 241. By 2002 UECCO was led by an Executive Committee of 10 elected members, of which one acted as a “Committee Member on Duty” on a weekly basis.

SIDA has drawn a number of success factors from this experience:

- Ability to provide long-term development support to the cooperative;
- Utilization of well proven technical solutions;
- Full ownership of the equipment by the cooperative;
- Strong local leadership and commitment involving influential individuals;
- A formalized legal structure;
- Training of the cooperative staff in technical and management matters;
- Transparent cash-flow management and treasury;
- Availability of an organization that can provide technical support when needed and without much delay

Source: Electrification co-operatives bring new light to rural Tanzania; Energy Policy 33; 2005

5.4. Non-conventional routes to electrification for rural households

Connection to the central grid is not the only way for rural households to access electricity. Household-based systems such as small diesel generators and solar home systems are other widespread options that need to be considered here.

A recent survey in Kenya for example found that in 64% of non-electrified localities in Kenya, diesel power generators are common, and in 65% individual solar home systems.[14] The survey underlines that “22% of the sampled households without public electricity were owners of solar panels”. These findings from Kenya suggest that solar energy has become a quite widespread non-conventional access route to electricity for the more well-off parts of the rural population. Studies of the *solar lighting industry* in different countries show that the sales, installation and maintenance of solar home systems are often developing into a flourishing and job-creating industry.

The penetration of solar home systems leads also to important secondary innovation effects because low-voltage electrical appliances such as LED lamps, TVs and videos are becoming available throughout the country. These appliances are not only relevant for solar home systems but are also used together with car batteries that are recharged from grid or diesel electricity. Battery recharging shops have become another flourishing business in most of rural Africa. The Kenya study for example reports that battery recharging shops using diesel generators exist in 14% of the non-electrified locations.[15]

The “Energy Kiosk” concept developed under the UNIDO SHP programme in Kenya builds on this trend by using re-chargeable lamps (and other battery charging techniques) instead of the conventional wiring of houses as a solution for electricity distribution to poor households. This new and low-cost approach to electricity distribution is easily accessible to private business models and thus has the potential of avoiding heavy cooperative management structures. However, as explained in chapter 8 below, UNIDO’s “Energy Kiosks” in Kenya are largely built on community based structures and thus suffering, to some extent, from the management problems that are typical for this approach.

5.5. The “Lighting Africa” initiative of the World Bank

“Lighting the bottom of the pyramid” and “Lighting Africa” are initiatives of the World Bank Group and the International Trade Centre (ITC). Aimed at providing access to non-fossil fuel based, low cost, safe, and reliable lighting products to 1.7 billion poor people worldwide, in particular to 500 million poor people living in Sub-Saharan Africa.[16]

The initiative targets the poorest of the poor, for whom lighting is often the most expensive item among their energy uses, typically accounting for 10-15% of total household income. Yet, while consuming a large share of scarce income, fuel based lighting provides little in return. The initiative has been triggered by new advancements in lighting technology, such as compact fluorescent light bulbs (CFLs) and light emitting diodes (LEDs), which promise clean, portable, durable, lower cost, and higher quality lighting. The challenge is to make these products accessible to the half billion "lighting poor" in Africa.

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[14] Updating of the Rural Electrification Master Plan; Socio-economic Survey and Rural Electricity Demand Analysis; Nairobi, September 2008

[15] p. 58

[16] http://lightingafrica.org/

With expenditures on fuel based lighting estimated at US$38 billion annually, the Lighting Africa initiative aims to engage the international lighting industry in this new market, while serving consumers, bolstering local commerce, creating jobs, enhancing incomes, cleaning the air, and improving health, safety, and quality of life.

Lighting Africa is a market based initiative that addresses international LED manufacturers and assemblers; companies already providing energy solutions to rural areas; companies with wholesale or retail distribution networks serving rural areas; companies seeking new marketing and advertisement opportunities in rural areas; NGOs promoting energy access for rural areas; local investors and entrepreneurs.

The basic idea behind these initiatives is to harness the power of public private partnerships while offering business opportunities to test and enter a large, undeveloped and high growth market for off-grid lighting solutions. Lighting Africa will seek to create innovative business models to deliver modern lighting to non-electrified rural areas, and is seeking to identify creative international and local entrepreneurs and investors.

“Lighting Africa” is being piloted in Ghana, Kenya, Zambia, Ethiopia and Tanzania. For each of these five countries three analytical studies are being prepared:

1. **Exploratory Qualitative Studies** consisting of both consumer and business interviews, including demonstration of sample products
2. **Quantitative Usage and Attitudes Study** consisting of consumer surveys (which took place during the months of May, June and July 2008, simultaneously in all 5 research countries)
3. **Product and Concept Testing Study** in parallel with a second qualitative study, to consist of in depth interviews and product placements in rural and urban households and micro-businesses, to take place in late fall 2008

The studies under 1) and 2) are already available from the “Lighting Africa” website and provide a wealth of information on the markets for low-cost high quality lighting in the five pilot countries.

To shield African consumers from poor-performing lighting products and avoid market spoilage, a product quality assurance program is under development to enhance consumer awareness, support the industry in providing technologies appropriately tailored to the African consumer base, and boost confidence in new lighting products and services.

In May 2008, the World Bank held its first Lighting Africa conference in Accra, Ghana, where it awarded prizes of up to $200,000 to 16 companies and non profit organizations for innovative "off the grid" lighting ideas.

An illustrative example is Lights for Life (LFL), a small nonprofit organization that has developed the "Portable On Demand" (POD) light and a charging device that can be powered by pedal, solar panels, or normal electricity. The PODs' first field trial, lending 20 fully charged POD prototypes to villagers, has been conducted in

2008 in the village of Gahembe in Rwanda as part of the Millennium Villages project, under the auspices of Columbia University's Earth Institute.

As part of the Ghana conference, a Quality Assurance Workshop was held with international experts to inform the design of the quality assurance program, which consists of the following complementary pillars:

- A product testing method and performance specification to aid bulk procurements
- A code of principles for industry stakeholders that ultimately should merge into a quality seal for off-grid lighting products
- A process by which periodic reviews of off-grid lighting products are routinely advertised (supported by a consumer education campaign) in the African marketplace

Currently, “Lighting Africa” is further developing these additional pillars in consultation with key stakeholders and with strong participation from industry.

The OSRAM programme promoting solar lighting systems for fishermen on the Lake Victoria is briefly described in Box 5.3.

Box 5.3: Osram’s Off-Grid Lighting Project

The sustainability branch of the German multinational company OSRAM pursues, among other sustainability-related projects, an “off-grid lighting project”. Starting point for this initiative has been the underlying figures from the “Lighting Africa” initiative that 1.7 billion poor people world wide spend about 38 billion USD per year on kerosene for lighting purposes. Thus, the lighting market of the “bottom billion” is dominated by oil companies, not by the providers of electrical equipment and lamps, such as OSRAM.

The pilot phase of the “off-grid lighting” project has been focusing on the Lake Victoria region where, according to OSRAM’s base-line study, 170,000 fishermen use 20 million liters of kerosene per year, a consumption of fossil energy entailing 50,000 tons of CO_2 emissions. The economics of the project were projected as favorable because fishermen dedicate up to 70% of their income to kerosene.

The Lake Victoria project has been thoroughly planned in cooperation with the University of Vienna using a total investment of 2 million Euros and a loan from a German development bank.

The core of the OSRAM approach are the so called “O-Hubs”, service stations where LED lamps are being recharged at a price fixed 20% below the expenditure for kerosene, while the 2000 Ksh (20 Euros) for the LED lamp is to be borne from a micro credit scheme. The anticipated benefits are: lower cost and better lighting for the fishermen; no emissions for more sustainability; a new business area for OSRAM and its local partners.

The first “O-Hub” was inaugurated in April 2008 in the Kenyan village of Mbita. However, by December 2008, the number of LED lamps sold remained still quite limited. Despite the favorable micro-economics (the cost of a LED lamp amounts to the total weekly income of a fisherman leading to a theoretical pay-back period of about 4 weeks) a lending scheme for lamps proved to be more attractive. In the meantime, the scheme has been extended to household lighting but the “productive use” lamps for fishermen seem to be driving the technology introduction process.

The intervention has been accompanied by a monitoring scheme. Detailed data on income and poverty impact are expected to become available at a later stage.

Source: No light for Africa; Die Zeit 03/2009; http://www.zeit.de/2009/03/Afrika and personal communication Mr. Gerhard Mair (University of Vienna).

The OSRAM programme is an interesting illustration for the philosophy and the difficulties of the renewable energy initiative of a large multinational company that tries to develop a new market for the "bottom billion".

5.6. The productive use of electricity

It is a widespread belief that rural electrification engenders economic growth and creates income opportunities. However, the evaluation evidence on this issue is mixed.

The latest World Bank evaluation of 2008 comes to *"the general conclusion from analysis of rural electrification programs that the impact on productive activities is limited"*. The evaluation finds that *"rural electrification does not drive industrial development, but it can provide an impetus on home businesses, even though few households use electricity for productive purposes"*. The evaluation concludes that the positive effects of the evaluated programs on household income were less than expected, except in those cases where the program had been accompanied by a specific program to promote productive uses of electricity.[17]

The earlier World Bank evaluation of 1995 had come to similar conclusions:

> *"Many of the benefits claimed for rural electrification have not materialized, or have been much smaller than expected. One of the most persistent claims for rural electrification is that it can induce industrial growth in otherwise lagging low-income rural economies. The evidence from developing countries does not support this claim; rural electrification has not, by itself, triggered industrial growth or regional development. In certain circumstances, however, it has supported growth led by a dynamic agricultural sector.*
>
> *The study found that where other prerequisites of sustained development were absent, demand for electricity for productive uses did not grow. (An important exception is demand for electricity for water pumping to spread irrigated farming.) Without agricultural growth, the use of electricity in rural areas has remained low, and many of the expected economic benefits of electrification have not been realized.*
>
> *Rural electrification reduces rural poverty only through a general rise in rural income obtained by productive uses. And - again with the exception of irrigation pumping - these productive uses of electricity appear to come about only when other factors are already raising rural and national per capital income, as has been the case, most noticeably, in Malaysia and Thailand"[18].*

[17] The Welfare Impact of Rural Electrification: A reassessment of the Costs and Benefits; World Bank Independent Evaluation Group; 2008
[18] Rural Electrification: a hard look at costs and benefits; World Bank OED; 1995

A recent study of rural electrification experiences in Tanzania, Zambia and Kenya, found that the productive uses of electricity in the rural areas studied are generally limited to low-load uses, such as lighting for extension of working hours for bars, groceries, etc. The study concludes that:

> *"Electricity by itself does not lead to sustainable economic development. Other causes than the mere availability and price of electricity are influencing the decisions of the local population and their opportunities to engage in productive activities"[19].*

In 1998 a study of the National Rural Electric Cooperative Association (NRECA) of the United States highlighted five key success factors for productive use programs:

- reliable and affordable electricity
- available and reliable electric tools and equipment
- available and affordable financing
- available and qualified human resources, and
- sufficient demand for the product or service

The study concluded that:

> *"Many productive uses programs have concentrated on only one of the five factors mentioned above, but for the program to succeed the other four have to exist. It does not mean that a program must build all five from scratch, but program implementers must ensure that the other components already exist in the target area or that the appropriate linkages can be forged with other actors that can make them available. The author considers that of the five, qualified human resources is the most important"[20].*

5.7. Conclusions

A number of conclusions can be drawn that are highly relevant for the evaluation of the UNIDO SHP programme:

- In most developing countries rural electrification programs are of high political priority. Typically, these programs serve political and social objectives. However, without corrective measures, rural electrification is characterized by an "anti-poor pattern". Many poor households which have the grid at their doorstep cannot afford grid connection, despite subsidies. "Electricity for the poor" programmes focusing on urban regions with a high *poverty density* can be expected to have a higher poverty impact than rural

[19] Ilskog, Elisabeth; And then they lived sustainably ever after; Royal Swedish Institute of Technology; 2008
[20] Kittleson, D.; Productive uses of Electricity: Country Experiences. Village Power Conference, Washington, DC; 1998

electrification programs, even if rural regions may be characterized by a higher *poverty rate*

- The tariffs for grid electricity vary widely across countries. In order to be competitive and attractive, SHP electricity must be significantly cheaper and at least of the same quality as grid electricity. Moreover, for SHP programmes to succeed at a national scale, government priorities and electricity market regulations ought to be in favor of SHP based alternatives

- In most rural electrification schemes, transmission and distribution are more important cost factors than electricity generation. Developing innovative, low-cost distribution systems is therefore as important as low-cost energy generation

- Mini-grids managed on a private or cooperative basis can be an alternative to central grid solutions. However, mini-grid management tends to be demanding and cost-intensive. The smaller a mini-grid, the higher will be relative importance of fixed costs such as maintenance and fee-collection. Cooperative management systems are an option but often require a high degree of formalization and intensive follow-up

- “Energy kiosk” systems reduce distribution cost by distributing electricity for lighting and other household purposes through rechargeable batteries instead of a grid. Such systems are an interesting low-cost option for electricity distribution, in particular for poor households. “Energy kiosks” can be run either privately or collectively

- Rural electrification does not, by itself, trigger industrial growth or regional development. Reliable and affordable electricity is only one key success factor for productive use. But at least four other factors must also be present: reliable electrical equipment; financing; human resources; and demand. To achieve significant impact on productive use, rural electrification needs to be accompanied by dedicated programmes

6

SHP based electrification

There is a wide-spread perception that SHP is more “pro-poor” than other forms of rural electrification. This perception is not necessarily in line with scientific literature and recent evaluations.

The already quoted evaluation of 120 rural electrification programs of the World Bank included a number of renewable energy based off-grid electrification schemes. While recognizing that such schemes can serve remote communities that may not be connected to the grid for some years to come, the evaluation underlines that, in general, off-grid electricity is more expensive than grid electricity and concludes that *“the economic rationale for funding off-grid components … is far from clear. Such a decision might be justified on social grounds, but the case is far from proven, especially when much lower subsidies would be required to reach the poor who are unconnected in electrified villages.”*

6.1. Some basic design and cost characteristics of SHP

Establishing the economic viability of SHP based electrification requires a detailed cost-benefit analysis and close scrutiny of the various cost factors.

When looking at SHP costs it should be reminded that SHP is often used as a generic concept covering hydropower units of different orders of magnitude ranging from 1kW to 10MW. However, the cost of electricity generation from SHP is subject to considerable economies of scale. The 2007 Global Status Report for Renewable Energies for example estimates the electricity generation costs of the various SHP technology options as follows (wind and solar energy included for comparison):

Table 6.1: SHP electricity generation costs

Technology	Power range	Generation costs (US cents / kWh)
Large hydro	> 10MW	3 - 4
Small Hydro	1MW – 10 MW	4 - 7
Mini Hydro	100kW – 1MW	5 - 10
Micro Hydro	1kW – 100kW	7 - 20
Pico Hydro	100W – 1kW	20 - 40
Wind	3kW – 100kW	15 - 25
Solar Home System	20W – 100W	40 - 60

Source: Renewables 2007; Global Status Report; Renewable Energy Policy Network for the 21st Century; www.ren21.net

Quite clearly, small-, mini-, micro- and pico- hydro power plants represent different scales of technology and each scale require different project planning, financing and management methods. Moreover, the appropriate user models depend on the scale of the mini-grid and thus differ between the various technology options.

Pico-hydro plants for instance are mostly used at a household level. Because the pico-hydro technology is quite cheap and not particularly sophisticated, these plants are normally installed by local craftsmen on the basis of tacit knowledge and without a feasibility study. Most pico-hydro plants are maintained by household members and thus do not involve electricity fees. But still, the specific capital costs of this technology are much higher than for micro- or mini-hydro installations.

Mini-hydro plants of several MW on the other hand involve considerable investment, which should normally be based on reliable multi-annual water flow measurements and professional feasibility studies. The business model for running such a plant requires formal management and maintenance structures and must also be in line with the rules and regulations for electricity generation and distribution.

Using the SHP concept in a generic fashion may therefore be misleading. The present evaluation deals with hydropower plants between 1kW and 200kW and thus spans across a whole range of technologies and intrinsically different business models.

Historically, most SHP have been direct drive technologies, such as water driven grain or saw mills. Although such direct drive applications may be considered archaic and marginal they still do exist in many countries. Successful SHP programs, such as the one in Nepal, have been built on promoting and upgrading direct drive technologies. However, none of UNIDO's SHP projects applied direct drive technologies.[21] The present evaluation covers only electricity generating SHP's, both off-grid and grid connected.

6.2. Basic design features of SHP

Besides scale, the feasibility and specific cost of a SHP plant is determined by several basic design parameters that are evoked here:

- Water supply should be sufficient throughout the year. Strong seasonal flow variations with strong peaks during the rainy season often require heavy civil construction works to protect the installation from damage due to flooding

- Low water flows during the dry season increase investment cost for off-grid applications because they can require hybrid solutions involving other sources of energy (e.g. diesel or solar)

[21] In Tanzania the opportunity for such an upgrading project existed but was not used.

- It is an important design feature whether an SHP shall feed into the grid or operate off-grid. On-grid installations tend to make better use of the available hydraulic resources than off-grid installations because the latter are normally designed for the minimum annual flow while the former can also make profitable use of part-time hydraulic resources

- High loads of sand and silt (in particular during the rainy season) reduce the life-time of turbines, valves and other mechanical equipment and require special construction features, which increase investment and maintenance cost

- SHP feasibility is constrained wherever water resources are scarce and used for competing purposes (e.g. for irrigation). Competing uses are particularly sensitive during the dry season

- Because seasonal variations of flow and sand/silt loads vary significantly over the years, hydraulic measurements must not be one-off exercises but should be multi-annual exercises (for larger installations covering at least five years). Average flow rates are not a useful information for SHP design

- The specific cost of an SHP turbine decreases with water head. Low-head turbines are more voluminous than high-head turbines and therefore relatively more expensive. In addition, low-head installations often involve more heavy civil construction works (dams), which can lead to prohibitive costs

- The distance between the powerhouse and the points of electricity use is of critical importance. Transmitting electricity over distances of more than about 2km involves stepping up transmission voltage (3kV to 11kV depending on distance and power). Transformers and other equipment required lead to a significant increase in installation costs

6.3. SHP for productive use

Two different cases of SHP for productive use can be distinguished.

The first case consists of a rural industry developing a SHP site as a source of energy for its production processes, while possibly selling surplus hydro-electricity, e.g. during evening and night hours, to households in the surroundings of the plant. In European history and also in many developing countries, this case has been typical for many SHP based industries, such as watermills for grain milling, textile and metal processing and timber sawing. A similar approach consists of upgrading the energy supply of an existing industry from non-renewable energy or grid electricity to SHP electricity. This approach has been adopted by a GEF financed UNEP project with the East African tea industry (see box).

Box 6.1: Greening the Tea Industry in East Africa

Greening the Tea Industry in East Africa, a small-hydro power initiative, is a project funded by the GEF, co-implemented by UNEP and the African Development Bank and executed by the East African Tea Trade Association (EATTA). The objective of this Small Hydro Power (0.2MW - 5MW) project is to reduce electrical energy use in tea processing industries in member countries of the East African Tea Trade Association while increasing power supply reliability and reducing Greenhouse Gas emissions. Specifically, the project aims to establish 6 small hydro power demonstration projects in at least 4 of the EATTA member countries, preferably with an attached rural electrification component as well as prepare additional pre-feasibility studies. Both studies and planned installations shall serve as training grounds for the entire tea sector in the region. A special financing window shall be designed that will provide incentives for individual tea processing plants to move into "green power generation".

Source: http://greeningtea.unep.org/

The second approach for developing SHP for productive uses consists of setting up a village scheme initially for lighting purposes and then promoting the use of electricity for productive purposes. This approach has been adopted, at least theoretically, by the UNIDO programme.

6.4. National context matters: two contrasting country cases

Success and failure of SHP electrification is not only dependent upon physical conditions but also on "soft" factors such as policies and national and local traditions.
The contrasting cases of China and Thailand are instructive in this regard and should be briefly mentioned here.
The case of China is often quoted as the most impressive success story for SHP development world wide.[22] China is currently operating 42.221 SHP plants with a total installed capacity of 28.489 MW, supplying electricity to more than 300 million people across 1501 counties (out of a total of 2300). 754 counties with about 280 million people have their electricity supply mainly from SHP. China accounts for 39% of the worldwide SHP capacity. [23].

The development of SHP in China has been an integrated part of the Chinese industrialization policy and cannot be disconnected from the specific conditions under which this policy developed. Since the 1950s the Chinese Government based the development of the country on the principles of self-reliance also known as the "Three-Self Policy". These principles applied to industrial development in general and to SHP development in particular. Over the years, this policy has taken different forms but the basic feature remained that *"from the beginning, the SHP stations and local grids were built by the local people with very little support from the Government."* During the late 1990s the State Power Corporation made attempts to take over the SHP stations and local grids owned

[22] Jiandong, Tong; Small Hydro on a large scale: challenges and opportunities in China; Renewable Energy World 6; 2003; p. 93
[23] Jiandong, Tong; Small Hydro Power: China's Practice; China Water Power Press; 2004

by cooperatives. This policy shift led to a significant slow-down of SHP development and was rapidly corrected.

Through the International Center and Network for SHP (IC-SHP and IN-SHP) China and UNIDO pursue a proactive policy of transferring Chinese SHP technology to other developing countries. However, Chinese experts underline that *"The rural electrification construction in China is unique and is completely different from the system of the western developed countries."*[24] Taking this into account, the Chinese experience cannot serve as a blue-print for transferring SHP technology into different socio-economic environments.

Thailand on the other hand is an equally well-documented but totally different case of a country where SHP development, despite positive physical and economic conditions, has never taken off to any significant extent. The environment and demography of Thailand are ideal for SHP development: steep hillsides are abundant in much of the north, northeast and south; rainfall is generous; and thick forest cover ensures that many streams have water throughout the year. Settlements in these areas are generally remote and sparse and decentralized electricity generation is potentially cheaper than extending the grid. Yet, by the year 2002 the national grid served almost 70.000 Thai villages but only 59 community micro-electric systems had been built. Moreover, two thirds of the existing SHP have been replaced by the grid or fallen into disrepair. In 2003, only 24 SHP plants were under operation.[25]

Why is SHP losing out to the central grid in Thailand? The 2003 survey covering 24 functioning installations in Thailand produced the following explanations:

- 20 out of 24 installations were plagued by endemic low-voltage periods during the critical evening hours when electricity demand reaches its peak ("brownouts")
- 16 installations had power outages due to equipment failures, the most frequent being generator failures (14)
- Problems were exacerbated by user behavior in which over-consumption by a minority of individual households leads to critical shortages for the community as a whole
- Because only one or two SHP plants are built every year there is only enough work for a single equipment manufacturer; lack of competition means lower quality and higher price equipment
- Villagers tend to perceive the arrival of the grid as a good deal: electricity from the grid is cheap because it is subsidized; it is essentially maintenance-free; it puts an end to "brownouts" and the social tension caused by adverse user behavior
- Electrifying SHP villages is also attractive for the electrification utility because these villages are good customers, who already own many electrical appliances and are accustomed to paying electricity bills

[24] Jiandong, Tong; 2004; p. 93
[25] Graecen, Chris; Small is pitiful: Micro-hydroelectricity and the Politics of Rural Electricity Provision in Thailand; Energy and Resources Group; UC Berkeley USA; 2003

The preference for central grid electrification in Thailand goes back to policy choices in the 1960s whose organizational and structural momentum continuously determines the electrification trajectory of the country.

The case of Thailand demonstrates that advantageous physical conditions are a necessary but not a sufficient condition for SHP development. It also shows how the sunk costs of a central grid, institutional inertia and socio-cultural traditions can combine to a country-specific electrification trajectory where introducing SHP can become virtually impossible.

In 2002 the Thai Government made an attempt to stimulate decentralized electricity generation alongside the traditional centralized grid. The cornerstone of this policy shift has been a new “net metering” law also known as “Very Small Power Producer” (VSPP) law.[26] The original VSPP regulations were modeled closely after net metering laws in the USA and other countries. The VSPP regulations allow customers with renewable energy generators (solar, wind, micro-hydro, biomass, biogas, etc.) to connect their generators to the grid and offset their consumption at retail rates. If a net surplus of electricity is generated, the Thai VSPP regulations stipulate that utilities must purchase this electricity at the same tariff as they purchase electricity from the state-owned generation company. In autumn 2006 this rate worked out to be about 3.8 baht per kWh during on-peak hours and about 2.0 baht/kWh for off-peak hours.

However, the difficulties of changing the electrification trajectory of a country are well illustrated by the fact that wind, solar and small hydro have still not proved viable despite the favorable tariffs offered in the VSPP programme.[27]

6.5. Conclusions

Different rationales and scenarios for SHP introduction can be derived:

1. Electricity for households with no or limited access to grid electricity

1.1. Very remote and thinly populated areas where the central grid will not arrive in the foreseeable future

1.1.1. Decentralized electrification at household level (pico-hydro competing with diesel or renewable energy-based home systems)

1.1.2. Mini-grids (micro- or mini-hydro competing with mini-grids powered from diesel other renewable energies)

1.1.3. Energy kiosk systems (pico-hydro power distributed via rechargeable batteries for lighting and other household purposes)

[26] http://www.netmeter.org/
[27] An emerging light - Thailand gives the go-ahead to distributed energy; Cogeneration and On-Site Power Production; March – April 2007

1.2. Regions with grid access (at present or in the foreseeable future) but where poor households cannot afford grid connection

1.2.1. Decentralized electrification at household level (pico-hydro competing with central grid)

1.2.2. Mini-grids (micro- or mini-hydro competing with central grid; possibly also mini-grids buying bulk electricity from the grid)

1.2.3. Energy kiosk systems (grid electricity or pico-hydro power distributed via rechargeable batteries for lighting and other household purposes)

2. SHP feeding electricity into the central grid (economic viability depends on "net metering" law that is advantageous for SHP)

3. Productive use programs

3.1. Accompanying conventional rural electrification programs with special measures for the promotion of productive electricity use

3.2. Offering SHP solutions to existing industries (possibly combined with distributing surplus electricity to households)

7

UNIDO SHP activities in Sri Lanka

7.1. Background

Since the middle of the 1990s Sri Lanka has stepped up the pace of rural electrification. It is estimated that, in 2007, the electrification rate had reached 80%, up from 40% in 1994. However, most of this increase comes from thermal electricity. While until 1995 virtually all electricity of the national grid came from hydropower, the hydro-thermal mix has deteriorated since to about 35%. The generation of hydro-electricity stagnates at about 3000 GWh per year while thermal power is up to about 6000 GWh. This increase confronts the country with sustainability issues and a significant foreign exchange burden.

As in other developing countries, Sri Lanka's aggressive grid expansion did not necessarily lead to better electricity access for the poorer parts of the population. It is estimated that only 60% of households in newly electrified villages gain access to the grid within two years of electrification while up to 40% remain permanently disconnected due to economic or technical constraints. Overall, the electrification rate of the poorest one-fifth of households in Sri Lanka is about 38%. The ADB funded "Power Fund for the Poor" executed between 2002 and 2005 addressed this problem. About 7,000 electricity grid connection household loans totaling about 1 million USD were disbursed under this fund.

Against this background it is not surprising that renewable energy alternatives, in particular those with poverty dimensions, are high on the agenda in Sri Lanka. There is a vibrant community of energy and environmental NGOs belonging to the "Sri Lanka Energy Forum", acting as some kind of an informal hub.

Financial support for renewable energy development comes mainly from the "Renewable Energy for Rural Economic Development" programme (REREP).[28] This World Bank funded scheme is considered highly successful. Between 1997 and 2002 the predecessor scheme ESD received World Bank funding of 17 million USD. Subsequently, REREP received 75 million USD covering the period between 2002 and 2008. Only recently, the World Bank accepted to fund the extension of REREP by another USD 40 million, until 2011.

ESD and REREP funding has been focusing on solar home systems and mini and micro-hydro electricity. By the end of 2007, the program had supported 115.195 households with the installation of solar home systems of 5,170 kW in total. 5,869 households were connected to micro-hydro-powered mini-grids of 1,432 kW in total.

[28] Ample information on REREP is available from www.energyservices.lk

7.2. Small-scale Hydropower

In many parts of the country the geographical and climate conditions are favorable for hydropower development. In the hilly and mountainous central and southern parts of the country the tea industry and other cash-crop industries early on developed thanks to shaft-power from mechanical hydro-plants. It is estimated that 500 micro-hydro plants were in operation on colonial plantations in the early part of the 20th century. Today, mini- and micro-hydro-electricity are well established technologies in these regions. However, significant parts of the country, in particular the Northern and Eastern regions, cannot access mini- and micro-hydropower to any significant extent, due to climate and geographical conditions.

The technology of micro-hydro powered village grids diffused to Sri Lanka from Nepal during the late eighties and early nineties. NGOs such as SKAT from Switzerland and ITDG from the UK played an active part in this process. But also UNIDO contributed to this successful South-South technology transfer by organizing training courses for water-turbine design around the year 2000.

An assessment of the small hydro potential in Sri Lanka carried out in 2001 identified an overall potential of 97.4 MW. of this potential 23.7 MW was found to be in old estate sites, of which only 10.4 MW were still in operation. The rest was abandoned or no more in operation.[29]

Box 7.1: Conclusions of a Sri Lanka case study in 2000

- Village hydro projects are primarily meant for off-grid rural electrification in remote locations and they tend to show poor financial viability on their own
- With a grant component similar to that of the ESD project, these schemes could be financially viable, but the electricity tariffs need to be kept at a reasonable level as in the case of Kandaloya site
- Within the community-owned village hydro (VH), small-scale individual endues activities such as battery charging and ice-making are more sustainable than large community-owned end-use activities such as rice milling
- Private, productive end-use activities such as electricity use in a tea factory make MH schemes very attractive in terms of their financial viability
- Extension of the national grid into areas where village hydro schemes have already been established jeopardizes cost recuperation, contributing to poor sustainability of these projects due to their customer base being affected
- It is worthwhile exploring the possibility of grid connection of such micro hydro projects as an end-use where excess energy can be sold

Source: Best Practices for Sustainable Development of Micro Hydropower in Developing Countries; DFID and World Bank; March 2000

[29] Fernando, Sunith; An assessment of the Small-scale hydro potential in Sri Lanka; Energy for Sustainable Development; volume VI; March 2002

Box 7.2: Effects and impacts of micro-hydro power in Sri Lanka

Electricity from micro-hydro projects has made a marked difference to the lives of the beneficiaries. Although there has been some improvement in their incomes especially in micro hydro projects, the main benefit has been in improving the quality of life through better lighting.

According to beneficiaries better lighting has made a significant change in their life that cannot be quantified. Electric lights were more convenient than kerosene lamps and also accident-free. Apart from this convenience, the smoke from kerosene lamps was harmful to their health. Electric lighting has created a more pleasant and happy environment at home for all members, particularly for women and children who spend most of their time at home. 82.0% of HHs has observed greater convenience for the work of housewives due to these changes. 74.0% of HHs has observed that husband and male members of the families stayed at home in the evening and devoted more time for family affairs and it has contributed to improve the family relationship. About 19.0% of HHs has noticed a reduction of alcohol consumption.

Apart from lighting, use of TV is the most widespread benefit. Its use has increased considerably between 2004 and 2007. Electricity has enabled them to use colour TV. Another benefit is the ability to use electric irons especially to iron children's school clothes. 20.0% of the HHs had used electric fans.

Some schemes have faced problems due to several reasons: poor construction, shortcomings in machinery and equipment, unsatisfactory maintenance and weak organizations. 16.0% of households were not happy with the quality of construction of the schemes. The reasons given by them were dim light (13.0%) and frequent power failures (22.0%). Consumers complained that VECS office-bearers used more than their fair share of electricity. Also, although everyone paid the same amount, some HHs used more than others.

According to the impact survey in the 4th quarter of 2004, 2.9% of households had identified micro-hydro electricity as an opportunity to start enterprises. There were three enterprises operating within the sample prior to receiving electricity and no new enterprises had been started after receiving electricity. As per the impact survey in the 4th quarter of 2007 which covered 92 HHs in 9 VECS areas, one enterprise had been started after receiving electricity. Data collected from these 9 VECSs showed that 29 enterprises used electricity from the micro-hydro projects:

- Carpentry sheds 16
- Grocery shops 5
- Grocery shops with Refrigerators 2
- Tea shops 2
- Sewing 1
- Grinding mill 1
- Battery charging 1
- Electrical repair 1

Only one employment opportunity (outside family) was provided by these enterprises. If we extrapolate from the 9 VECSs to all the VECSs that receive electricity from micro-hydro sub-projects, it suggests that 367 enterprises in the 114 subprojects use electricity. However, data collected from 73 VECSs through a postal survey indicated that there might be only 82 enterprises in the 88 sub-projects in operation at that time. The available data do not reflect a significant impact on the rural economy but these enterprises serve a useful purpose in meeting local community needs.

Source: Bi-annual M&E Report of REREP; March 2008

Since 1990 the number of micro-hydro village schemes increased from 10 to over 300. The ESP and REREP schemes played a significant role in this process and the experiences gained under these programmes are highly instructive for current and future activities of UNIDO in the mini- and micro-hydro field.

So called "promoters" play a key role under REREP. Such promoters are basically NGOs or private consultants who accompany a micro-hydro scheme from identification to full operation. The different stages of this process span from period of about one to two years from identifying a potential micro-hydro scheme, preparing a pre-design, gaining confidence of the village community, helping the community with establishing a so-called "Village Electricity Consumer Society" (VECS) as a recognized legal entity, submitting a financing proposal to RERED, designing the scheme on the ground, supervising the civil works conducted by the villagers and the installation of the equipment and the mini-grid by subcontractors and supporting the VECS with management issues.

An average micro-hydro village grid in Sri Lanka is equipped with a 10 to 25 kW turbine (mostly of the Pelton type) and supplies electricity to about 25 to 100 households (the average installed power per household is about 250 W). RERED estimates the cost of setting up such a scheme at about 40,000 USD. 8,000 USD of this amount are paid as a lump sum to the developer who receives this amount in several installments depending on successful progress and quality control by chartered engineers at critical milestones of the construction process. This modus operandi is one of the improvements introduced under REREP as compared to the initial ESD fund. Other improvements have been the selection of a limited number of "quality labeled" promoters based on experience and reliability. At present, nine promoters are officially recognized by RERED.

It should be underlined that UNIDO has successfully transferred micro-hydro know-how from Sri Lanka to Rwanda by using the company Hydropower International for the construction of four micro-hydro power schemes in Rwanda (see the Rwanda country report of the present thematic evaluation). Hydropower International belongs to the pool of officially recognized RERED developers. Against this background it is quite surprising that UNIDO contracted, under its own Sri Lanka project, a consultant who is not recognized by RERED (see below).

Box 7.3: Experience of a communication and computer training center in Sri Lanka

The village communication center had been started by a lady teacher who is also the treasurer of the VECS. Similar to households the centre has been affected by power cuts. However, business of the communication centre has declined anyway with the introduction of mobile phones and this activity has now ceased.

Another teacher has started a computer training centre which is located in the school. He wanted to introduce computer knowledge to the school children and a friend of him agreed to teach the computer classes that are being held at the weekends and on Wednesdays after school. He follows the GCE “O” level IT syllabus and the students who follow the classes get a certificate and can also sit for this subject at the “O” level examination. Each course is taught for 60 hours during 3 months. 24 students joined the current course; 6 of them have dropped out and 18 are continuing. About 100-110 have been trained up to now.

The teacher started with the computer of his son. Later on he bought another computer for Rs.17, 000/=, for which he received Rs.7, 500/= assistance from FECS. His old printer had broken down but someone who visited the project gifted a color printer. The power supply has been good and he has not had any problems with the computers so far. The teacher is able to attend to minor problems. Students pay Rs.500/= admission fee for printed materials and stationery and Rs.125/= of monthly tuition fees for 3 months. The costs are Rs.600/= for materials, Rs.100/= per month for electricity and; Rs.2, 000/= per month for the instructor (according to the FECS report) He does this business mainly to help the community. He does not make much profit but he is able to cover the costs and have a little surplus.

Source: Bi-annual M&E Report of REREP; March 2008

It is quite remarkable that Sri Lanka has over the last 10 years, developed a national capacity in the production of water turbines. While the first village schemes, during the 1990s, were equipped with Chinese turbines, today almost all schemes are equipped with Sri Lankan turbines. The number of turbine manufacturers in Sri Lanka has, however, come down from 12 in the year 2000 to five in 2008, which could be seen as a sign of maturity. The leading manufacturer of micro-turbines in Sri Lanka is REDCO.[30] This company also acts as a site developer and has equipped all of its 55 sites with self-manufactured turbines: 50 Pelton and 5 Cross-flow turbines of a power range between 3 kW and 30 kW. The company also equipped a grid-connected site of 60 kW with one of its turbines.

It has been an important boundary condition for the development of village schemes that Sri Lankan law does not allow VECS selling electricity to their members. Logically, village schemes are not equipped with electricity meters but the VECS execute an inspection right, by which they control that households do not exceed the agreed 250W of electrical appliances that are considered acceptable by household. This system has obvious egalitarian effects on VECS members but entails also social tensions among them in case of non-respect of the rules. Moreover, the system does not favor the commercial use of electricity for productive purposes or a for-profit basis.

[30] www.redcoenergy.org.lk

Box 7.4: Experience of a hairdresser with SHP electricity in Sri Lanka

We interviewed Samapala Sunanda at his home next to his saloon. He had been providing saloon services even before the micro-hydro project was established. After electricity became available he modernized the saloon in 2006 with electrically operated equipment. He received financial assistance from FECS for that (Rs.5, 000/= in 2006 and again in 2007).

When electricity was available business was good. During the New Year festival season, he earned as much as Rs.10, 000/= a month. During the past year, there have been regular breakdowns of the electricity supply due to the motor getting burned and for the past 6 months there has been no electricity. As a result there is a reduction in customers, especially young men because it is not possible to do hair styling without his electrically operated equipment. Now he does not earn more than Rs.50 – 60/= a day mostly from the older men in the community. Women in the community do not avail themselves of his services as it is not customary for them to cut their hair. As a result he has to restart some of the other activities he did earlier such as making ornamental plants and flowers and cement flower pots.

He and two other members of the community who were present at the interview had many complaints about the VECS. According to them, the project worked well during the first few years. They have already paid up the bank loan. For several months now, there have been problems with the motor. It burns from time to time. For some time now power was provided on a restricted basis but since the present office-bearers took charge, there has been no power for the past 6 months. Money has been collected from time to time to repair the motor. By now members of the community have spent Rs.70, 000 – 80,000/= but do not have electricity. They use kerosene again (nearly a bottle a day) and it costs Rs.80/= per bottle. As VECS has not met, they do not know what is happening.

Source: Bi-annual M&E Report of REREP; March 2008

Despite the extraordinary success of micro-hydro village grids in Sri Lanka, the quick expansion of the number of schemes has also led to a number of problems such as: deteriorating quality of technical services; overload of mini grids by too many households or too many appliances by household; members loosing faith in their VECS due to poor accounting systems and misuse of funds; formation of fractions within the society leading to disputes between members. To address these problems the Energy Forum established a Federation of Electricity Consumer Societies (FECS), initially with a membership of 38. Today, the FECS has 150 members who represent about 6,000 micro-hydro powered households. The FECS represents micro-hydro users' vis-à-vis the national and regional administration, has conducted skills development workshops for 384 ECS leaders on organizational and management issues and rehabilitated sub standard schemes.

The FECS has also been a leading player in promoting income generating activities in micro-hydro villages. From the beginning, promoting productive use has been an integrated part of REREP. Productive activities that are typically supported under REREP are low-energy applications such as tailoring shops; hair saloons; battery chargers; computer facilities; refrigerators in stores and restaurants and carpenters. In one particular case an innovative spice drier has been developed with special support from a so-called "Innovation Solicitation Contract" funded by REREP. Despite these efforts and the existence of special funding opportunities, the promotion of the productive use of micro-hydro electricity has not yet developed as expected. This confirms the widely established experience that, although electricity is an enabling factor for the development of village industries, the availability of electricity alone is not sufficient for such industries to emerge on a significant scale.

Another critical development, attracting stakeholder attention, is the constant advancement of the national grid into new rural areas. In order to avoid obsolescence of formerly isolated micro-hydro grids the FECS has been lobbying for a "net-metering law". A related cabinet decision has been reached only recently. "Net metering" is expected to create opportunities for income creation through feeding micro-hydro electricity into the grid for those ECS that have become connected to the grid. However, the practical implementation of this decision by the CEB may require further lobbying efforts.

Box 7.5: Experience with commercial ash pumpkin preservation (puhul dosi)

M. Abeysinghe has been making *puhul dosi* for a long time. He had learnt the method of making *puhul dosi* at a training course in Alubomulla and had learned this technique in a factory before he started to make *puhul dosi* on his own. He obtains puhul from Embilipitiya. The other ingredients are obtained from Yatiyantota and Colombo. The main source of energy is firewood. He employs 4 – 6 persons for processing which is quite labor intensive. They are paid Rs.600/= per day when there is work but there is no work every day. Electricity is used only for lighting and sealing the polythene packs. It is important to have electricity for lighting as it is possible to get the correct coloring by visibility only with electrical lighting.

The cost of ingredients and transport has gone up so much that M. Abeysinghe finds it difficult to make a profit unless he operates on a larger scale. For this he would need about Rs.100, 000/= working capital but he found it difficult to get a loan from a bank. As a result he has stopped making *puhul dosi* at present. This is a loss for the community as his enterprise provided work for about 4 persons and lorry and tractor hire to transport the raw materials and finished product.

Source: Bi-annual M&E Report of REREP; March 2008

On a larger scale, mini-hydro plants between 100 kW and 10 MW feeding into the CEB grid have become a profitable business in Sri Lanka. Reportedly, the pay-back period of such a plant, financed by subsidized REREP loans, can be expected to be as short as 4 to 5 years. 39 grid connected mini-hydro plants were set up under REREP by March 2008 with a total capacity of 87.3 MW (as compared to 1,135 kW for micro-hydro). The carbon emission reduction that resulted from mini-hydro plants, since the start of REREP until March 2008, is estimated at about 930,407 tons of carbon dioxide. Compared to this figure the emission reduction resulting from micro-hydro schemes is insignificant.

7.3. The DENDRO technology

Besides the well established micro- and mini-hydro plant and solar home system technologies, the so called DENDRO technology is attracting attention in Sri Lanka. This well-known energy technology obtains the so-called “producer gas” from burning wood or other dry biomass under controlled high-temperature conditions. This gas is then used for process heat or as a fuel for internal combustion engines. DENDRO is a relatively complex technology, which is not to be confused with biogas technology. The core piece of equipment of a DENDRO plant is the gasifier where a constant flow of dry biomass passes over a high-temperature bed of charcoal, where it is gasified. In order to remove tar and ashes, the producer gas is conducted through a series of filters. In general, a DENDRO plant requires an electrical pump in order to maintain a constant flow of cooling water, which is also used for filtering and cooling the producer gas. Having passed the filters and the cooling system the producer gas arrives at the motor and generator set.

The staff operating the DENDRO plant need to be well trained and acquainted with maintaining a relatively complex technical system. The filter system needs to be cleaned periodically and the charcoal bed needs to be replaced after a certain number of operating hours. Furthermore, the operation of a DENDRO plant depends on the availability of a constant flow of wood or other lignite biomass. To avoid clogging and other problems in the gasification unit, the feeding material needs to be dry and chopped to a constant size. The preparation of feeding material, thus entails additional energy and manpower cost.

All in all, DENDRO is an industrial technology that is well adapted to substitute fossil fuels in biomass related industries. However, it is widely recognized that the operation of this technology outside an industrial setting is technically challenging.

In Sri Lanka, DENDRO has been experimented in various forms. Under a UNDP funded project the Government Agency for Sustainable Energy tested the application of DENDRO technology in the lime stone and brass melting industries. In both cases the technology was found to be technically viable but both industries found the operation of a DENDRO plant too difficult and demanding for adoption on a day-to-day basis. More recently and apparently with greater success, DENDRO has been introduced for process heat purposes to the ceramics and footwear industries.

The “Energy Forum” tested a DENDRO plant in the village of Wadagahakiwla in the Mongeragala region with contributions from REREP, UNDP, GEF/SGP and the Ministry of Science and Technology. Although this pilot test had to be abandoned because the village became connected to the national grid it led to the following conclusion:

> *“Capital and running costs of off-grid DENDRO power are high compared to village hydro power. Hence it is appropriate to integrate an income*

generating activity at the design stage of the power plant. It is better to concentrate on the off-grid villages that could provide fuel wood to grid connected DENDRO plants as they can afford to pay running costs due to the additional income they get from selling the fuel wood."[31].

Wadagahakiwla is the only DENDRO powered mini-grid that has been trialed to date under REREP. At the current stage of development, REREP does not consider this technology as a viable solution for village electricity.

There are three manufacturers of DENDRO systems in the country, one of which has recently come up with an advanced technology that uses dry filters instead of water based cooling and filtering technology. Because of its relative simplicity this technology is considered as potentially interesting for village applications. It seems that six of these units are currently being tested.

7.4. The UNIDO renewable energy project in Sri Lanka

In 2005, the Renewable Energy Unit of UNIDO launched the project *"Establishing sustainable, economical and secure local resource-based renewable energy backed Community Development Centres with ICTs for post conflict and remote rural areas of Sri Lanka"* as part of the second phase of the Sri Lanka Integrated Programme.

The project document describes the project objective as follows:

> *"The main objective is the upliftment of the people in the off-grid villages, especially in post conflict zones from their present socio-economic situation with the help of renewable energy systems including SHP and the establishment of Community Development Centres, which would facilitate the growth of industry, sustainable agriculture, healthcare, education ICT facilities and the use of electricity into all possible aspects of rural life. Serve as a demo project for duplication in similar conditions in other areas of the country"*

The project document does not distinguish between development objectives and immediate objectives and does not provide indicators. There is only one project output mentioned:

> *"Implement model hybrid renewable energy systems including micro hydro power units, biomass, and biogas systems for powering Community Development Centres, along with training and capacity building of local personnel."*

This output is to be achieved by the following six activities:

- Preliminary energy survey and study
- Study tour

[31] E-scene: A publication from Energy Forum of Sri Lanka; July 2006

- Design and implementation of appropriate renewable energy hybrid systems
- Implementation of five Community Development Centres: Creation of Rural Training and Communication centres facilitating vocational training, internet communications and tele-health centres
- Design tiny/cottage/Small-scale industries/service outlets, which could provide an array of opportunities for income generation and social development resulting in improved standard of living
- Capacity building of users and supporting institutions

Annex 1 of the project document briefly describes five potential micro hydro sites identified by the Ministry of Energy and the Energy Conservation Fund. Annex 2 describes the design of a typical hydropower project (25 kW; 100 households; 10 computers; one sewing machine; one paddy dehusker).

The project budget of 301,032 USD has been financed by equal contributions from India and Austria. Project implementation started in 2005 with an identification mission of the then project manager from UNIDO Head Quarters. In August 2005 the UNIDO project manager hired a national project manager who has been under renewable UNIDO contracts ever since. Because this project manager is not one of the nine micro-hydro developers, who are recognized by REREP, UNIDO has also contacted a recognized developer (REDCO) but no agreement has been reached to date, on an appropriate distribution of work between them and the national UNIDO project manager.
The five micro-hydro sites pre-identified in the project document turned out not to be viable for various reasons and primarily because of grid proximity. Therefore, the initially envisaged location of the project site in either the Southern, Northern or Eastern regions of Sri Lanka had to be abandoned.

The identification of the site became even more complicated because of the specification that the demonstration plant should be a "hybrid" plant using hydropower and DENDRO power in parallel. The only site that was found to be appropriate for receiving a combined micro-hydro and DENDRO plant was Meemuray, a remote village in the central region that is located in the buffer zone between a forest reserve and a national park. Because of this, quite unique position, Meemure is indeed unlikely to be reached by the national grid within the foreseeable future. However, the site is also subject to a specific environmental permission regime.

As could have been expected, the process for obtaining the necessary permits has been long and tedious. In the meantime REDCO has prepared a feasibility study for the micro-hydro part of the project but, almost four years after the project started, the permit for the micro-hydro plant is still pending.

Moreover, there are serious doubts as to whether the donated technology from China (combination of a 10 – 150 kW turbine with a 10 kW generator) is appropriate for the Meemuray site. According to the national project manager the purchasing of a more powerful turbine is being considered.

The DENDRO part of the project is slightly more advanced. Tests of the DENDRO plant purchased from India were initiated on 8 August 2008 by the

UNIDO national consultant. This was immediately followed by an official inauguration of the installation by the Additional Secretary of the Ministry of Industrial Development and the UNIDO National Director, on 16 August 2008.

According to the reports from the national project manager the plant was tested between 16 August and 26 September for about 4 hours a day. During these tests the project manager identified the following long list of problems:

- The capacity of the wood chopper that was delivered from India together with the gasifier is more than 50% under the necessary capacity; due to overload the chopper motor got burned

- The capacity of the wood dryer supplied with the gasifier that was also delivered from India together with the gasifier is also below capacity

- The electrical power available during the tests was about 13 kW, which is 25% below expectations of 18 kW

- The manufacturer notice mentions two gas blowers but these were not included in the delivery; this may be one of the reasons for limited power

- Frequent choking of the gasifier causes frequent need to replace the charcoal bed, which causes additional cost because the charcoal available at the project site is not appropriate

- The gas filter requires saw dust of a specific quality that is not available on site and needs to be purchased at additional cost from a sawmill at 60 km distance

- The tests have been run without a load controller; it is unclear whether the electronic load controller designed for micro-hydro power plants that is envisaged to be used with the DENDRO plant is appropriate

- Problems with the water pump caused overheating, melting of the plastic tubes that conduct the producer gas between the different components of the filter system and eventually frequent shut downs of the entire system

- It is questionable whether the operation of the system complies with the rules and conditions laid down by the Central Environmental Authority under the environmental protection license issued for the DENDRO plant

- The tests were run by the national project manager without a specialist; technical assistance for the tests could be sought from a company that represents the Indian manufacturer in Sri Lanka but negotiations with this company are inconclusive

- Another installation initiated by another Ministry has become active nearby and is planning to provide electricity free of charge and also to pay for village labor; this causes irritations and affects the motivation of the Meemuray community

The tests confirmed the complexity of the of the DENDRO technology, which is a well known fact among renewable energy specialists and which had also been demonstrated by previous trials of this technology in Sri Lanka. However, difficulties encountered were aggravated by the random testing approach, apparently without any preparatory technical and economical analyses, and the obviously limited expertise of the national expert.

7.5. Self-assessment by Project Manager

The current project manager "inherited" the project from the initial project manager after about one year. In her self-assessment report the project manager raises the following critical points:

> *"The major issues and problems affected the implementation of the project are the delay of customs clearance for equipment, the procurement of mini hydro equipment prior to site identification. In addition, it would have been more cost effective and efficient to have the services for establishing the biomass gasifier and the mini hydro plant procured through turn-key subcontracting."*

The self-assessment does not shed light on the country background and assesses the relevance and effectiveness of the project as high. The concluding remarks of the self-assessment are surprisingly positive and to some extent misleading:

> *"The project achieved around 60% of its objective. Project impacts are significant on the quality of life and income of the community through having access to modern energy."*

7.6. Assessment of UNIDO's SHP project in Sri Lanka

According to established rules an independent evaluation is to be based on the initial project plans included in the project document and on possible updates, in case such updates of the project document are available. In the present case no such updates have been provided.

7.6.1. Relevance

The project objective mentioned in the project document is composed of multifaceted and vague sub-objectives at different levels. Both the higher-level sub-objective of "uplifting" the socio-economic situation in the off-grid villages and the idea of "duplication in similar conditions in other parts of the country" are not sufficiently specific for detailed evaluation.

Government officials and stakeholder representatives interviewed during this evaluation had difficulties to understand why UNIDO had ventured into setting up yet another micro-hydro site in a country where already more than 300 such sites have been successfully developed and where well-established financial and market mechanisms exist for developing as many micro-hydro sites as technically, economically and socially feasible. As one Government official put it: "*With this project, UNIDO should have come 10 years earlier.*"

The relevance of the DENDRO component of the project, which is strictly speaking not part of this evaluation, may be considered more favorably because this technology is still subject to experimental and explorative projects. However, the approach, how this technology has been experimented under the present project, has been ineffective as it will be explained below.

Relevance was further eroded, almost to a negative degree, by the decision to rely on imported instead on locally manufactured equipment. The manufacturing of micro-hydro and DENDRO equipment is state of the art in Sri Lanka. Several manufacturers exist for micro-turbines as well as for water-turbines in the range up to several MW. One local manufacturer has successfully developed an advanced DENDRO technology, which is currently being piloted at six different sites. Under these conditions, the project strategy of importing equipment and giving it away for free is more than questionable because it distorts the market and undermines the position of local manufacturers.

The most bewildering question with regard to relevance is why UNIDO did not grasp the most obvious opportunity of targeting the more than 300 existing micro-hydro villages for pursuing its declared objective of promoting the productive use of hydro-electricity. It is indeed difficult to understand why UNIDO ventured into developing an additional site instead of lending its support to the Federation of Electricity Consumer Societies and other stakeholders who are trying to develop Small-scale industries in these villages where the use of micro-hydro energy for household purposes is already well established, by taking advantage of the existing specialized facility of REREP.

Government and stakeholder representatives clearly expressed their expectation that UNIDO should, in the future, pay tribute to its core mandate. Any activity that might contribute to developing the productive use of currently unused day-time hydro-electricity in the existing micro-hydro villages would be considered as highly relevant.

Moreover, there is a clear opportunity for UNIDO to add specific value added and build synergy with the Trade Capacity Building component of the Integrated Programme by building on the already existing attempts, in some of the villages, to use micro-hydro power for developing export-oriented small-scale food industries.

7.6.2. Effectiveness

The evaluation revealed serious shortcomings as to the effectiveness of the project strategy, which apparently aimed at income creation and poverty alleviation through establishing renewable energy powered Community ICT Centers. The project document remains more than vague with regard to this strategy:

"Rural electrification could bring multifold benefits, which include access to power for the socially deprived groups, enhanced educational and health care services, access to ICT systems, assist in the commencement of new Small-scale industries etc. The value added services like agro processing units, communication kiosks, health care centers, etc, that could emerge in the villages will result in more local employment opportunities; all these ultimately leading to sustainable development. This project through the establishment of renewable energy powered Community Development Centers in off-grid rural areas of Sri Lanka aims to prove the viability of such technologies for socio-economic development" (p.6)

"The project would also result in enhancing the competitiveness of rural youth, employment to at least a limited number of rural population and empowerment of rural society through information helpful to agriculture and other avocations and on market conditions, in addition to improvement to the local environment, such as improved air, water and land quality and consequent beneficial impact on the health of rural people. Another beneficiary will be school going children as no any average village person will have computers in this country" (p.7)

The project did not yet apply this "strategy" in practice because, after more than three years, none of the envisaged five Community Development Centers had been set up. However, the obvious lack of intellectual rigor of the analysis raises serious concerns not only with regard to the potential effectiveness of the strategy, should it be put into practice at some stage, but also as far as UNIDO's quality control mechanisms for project documents are concerned.

Serious concerns exist not only with regard to the effectiveness of the project strategy for energy use but also to the envisaged solution for energy generation. In particular it is not clear, on which basis the decision for a hybrid solution combining hydro- and DENDRO technologies was made. Quite clearly, the cost of producing energy with a dual technology solution is much higher than the cost of energy production based on a single energy resource. Hybrid solutions entail not only double investment costs but also double technology introduction costs, e.g. for training and infrastructure.

Moreover, it is one of the basic features of renewable energy technologies that these solutions are site-specific (much more than fossil energy technologies). Due to geographical and climate conditions a given renewable energy technology is in most cases more advantageous in one region than in another. In the case of Sri Lanka, for example, it is widely recognized that micro-hydro plants are particularly appropriate in the hilly and humid regions of central and southern Sri Lanka, while the more complicated and costly DENDRO technology is primarily considered for the dry and flat regions of northern and eastern Sri Lanka, where micro-hydro is not an option.

In the case of the UNIDO project, the necessary site-specific characteristics of the micro-hydro and DENDRO technologies causes difficulties in finding a site that would be equally appropriate for both technologies. Even under the assumption that the micro-hydro / DENDRO hybrid solution is appropriate for the particular site of Meemuray it is quite obvious that these site characteristics are too specific for a wide-spread replication of this hybrid technology.

It is therefore not clear why the decision for a hybrid solution has been made. The project document does not include any considerations that would justify such a solution, nor does it present a technical or economic feasibility study for a hybrid plant. It appears that the decision for a hybrid solution has been driven not so much by demand but primarily by technology considerations and more specifically by the donation of a water-turbine from China and the purchasing of a DENDRO plant from India, one of the two donors of the project.

7.6.3. Efficiency

The planning and implementation of the project were marked by considerable inefficiencies. The planning process was inefficient because it failed to apply the logframe approach. The project document uses unverifiable and vague objectives and outputs, confuses outputs with activities and includes no indicators and no assumptions. It is therefore not in line with UNIDO quality standards.

Two aspects should be considered with regard to the question why such a poor document could pass the quality assurance mechanisms at UNIDO. Firstly, the mechanisms for controlling the technical content of the document in the originating branch seem to have been relatively weak at the time when the project document was prepared. Secondly, the labeling of the project as part of the Integrated Program contributed to lowering the formal standards of external quality control at the approval stage while, on the other side, there have been no efforts for building synergy with the other components of the IP.

Considering the financial efficiency of the project at the planning stage it should be reminded that the REREP program considers 40,000 USD as an average cost for a 30 kW standard micro-hydro plant together with the mini-grid. Even if the UNIDO project included, in addition, a community centre with 10 computers and a rice dehusker for each site the initial project budget of more than 300,000 USD for five village schemes appears to be somewhat exaggerated.

However, the implementation of the project has been far less efficient than the initial planning, due to questionable management decisions.

The decision of hiring a national project manager on a full-time basis instead of using one of the officially recognized site promoters on the well-established lump sum basis is incomprehensible. Although, the national project manager has been contracted continuously for more than three years he only identified one site instead of five as initially planned and did not even manage to obtain the necessary permissions for this site. Moreover, with a view to accessing REREP funds, the project manager has approached REDCO, one of the leading developers.

The decision of using imported equipment has been another source of inefficiency, which was made worse by the Government's decision of levying taxes on all equipment imported by UN projects, while the project had not budgeted for such taxes. When the counterpart Ministry accepted to pay these levies from the national budget almost 12 months had elapsed. The amount of import taxes (32,000 USD) equals almost the total cost of a Sri Lankan standard micro-hydro scheme equipped with a turbine.

7.6.4. Ownership and sustainability

By its design, the project should have involved the Ministry of Power and Energy in addition to the traditional UNIDO partners, which are the Ministries for Science and Technology and for Industrial Development. One of the organizations, under the authority of the Ministry of Power and Energy that would have been of specific interest for the project is the Sri Lanka Sustainable Energy Authority (formerly the Energy Conservation Fund). This organization plans and implements all renewable energy promotion initiatives and activities in Sri Lanka and is also the counterpart of the REREP programme. Nor have there been formal and official ties established by the UNIDO project with REREP, nor with the Energy Forum or other NGOs that are active in the renewable energy sector.

Overall, the anchoring of the project in the institutional landscape of Sri Lanka has been limited. The national project manager managed the project as a “closed shop”, without any significant involvement of national implementation partners. Project ownership of the regional and local authorities seems to be limited because, three years after the start of the project, the permission for constructing the micro-hydro plant has still not been granted. The Ministry of Industry, however, demonstrated remarkable project ownership by financing the import taxes for the imported equipment.

At the present stage sustainability issues are only hypothetical since the delivered equipment is functioning. The absence of a comprehensive technical and economical feasibility study for the project, the considerable delays and technical problems encountered and the fact that 70% of the budget are already consumed while the micro-hydro part of the Meemuray pilot site has not even started make it rather unrealistic that the project will reach its objective of implementing five renewable energy based Community Development Centres in Sri Lanka. Moreover, it is also unlikely that the Meemuray pilot site with its hybrid renewable energy plant will enter into operation as planned.

8

UNIDO SHP activities in Rwanda

The Government of Rwanda conducts a very proactive Electrification and Renewable Energy (RE) policy. Since 2005, the State Minister for Energy has reorganized the Energy Department of the Ministry for Infrastructure (MININFRA) and reinforced the Ministry staff by a team of young energy specialists. The capacity of the Ministry is further strengthened by a number of international experts of various bilateral donors, such as the Belgian, Dutch, German and European Cooperation. All these experts are working from MININFRA premises.

UNIDO adopted a different mode of cooperation. Although it has been the most longstanding partner of the Ministry in the area of Renewable Energy, UNIDO did not focus on policy advice and capacity building but on the construction of SHP demonstration plants. UNIDO manages these interventions from Headquarters without the presence of a UNIDO expert in the Ministry.

8.1. UNIDO's SHP projects in Rwanda

UNIDO's project portfolio in Rwanda includes the following eight ongoing and finalized projects in the area of renewable energy.

Table 8.1 UNIDO renewable energy projects in Rwanda

Project Number	Start	Project Title	Budget
UBRWA00D05	2000	INTEGRATED PROGRAMME FOR CAPACITY BUILDING TO ENHANCE INDUSTRIAL RECOVERY, COMPETITIVENESS AND SUSTAINABILITY	$17,086
XARWA03656	2003	RURAL ENERGY DEVELOPMENT	$18,714
YARWA03412	2003	RURAL ENERGY DEVELOPMENT	$76,334
YARWA05001	2005	DEMONSTRATION PROJECTS AND CAPACITY BUILDING PROMOTING A PARTICIPATIVE AND AFFORDABLE APPROACH TO RURAL ENERGY DEVELOPMENT	$55,304
XPRWA05002	2005	DEMONSTRATION PROJECTS AND CAPACITY BUILDING PROMOTING A PARTICIPATIVE AND AFFORDABLE APPROACH TO RURAL ENERGY DEVELOPMENT	$246,972
SFRWA06001	2006	RURAL ENERGY DEVELOPMENT: MINI HYDRO DEMONSTRATION PROJECTS - LEARNING BY DOING PROMOTING AFFORDABLE APPROACH TO RURAL ENERGY	$1,194,690
YARWA06002	2006	RURAL ENERGY DEVELOPMENT: MINI HYDRO DEMONSTRATION PROJECTS - LEARNING BY DOING PROMOTING AFFORDABLE APPROACH TO RURAL ENERGY	$61,521
XPRWA06003	2006	RURAL ENERGY DEVELOPMENT: MINI HYDRO DEMONSTRATION PROJECTS - LEARNING BY DOING PROMOTING AFFORDABLE APPROACH TO RURAL ENERGY	$84,807
Total			**$1,755,428**

Source: UNIDO Infobase

The total financial volume of these projects exceeds 1.7 million USD, with seven smaller projects being financed from UNIDO programmable funds and one large project funded by the Government of Rwanda (Table 8.1). All of these projects originated from phase 1 of the Integrated Program in Rwanda under which a small amount of “UNIDO seed money” had been allocated to the renewable energy theme. A new project aiming at “capacity building through technical assistance for MINIFRA to implement policies on rural energy for productive use” is currently being developed under the One UN program for Rwanda launched in 2008.

8.2. The SHP identification study of 2004

The first three projects of the RE portfolios were launched in 2000 and 2003. These projects were primarily dedicated to a series of identification and pre-feasibility studies, one of which was issued in July 2004 under the title of "Capacity building and studies for a micro hydro project implementation". This study was prepared by an SHP expert from Sri Lanka contracted by UNIDO who had visited two potential SHP sites in March 2004 together with a group of eight officials from various Rwandan ministries. The study adopted "participative and affordable" and "learning by doing" approaches, which also became the underlying philosophy of the subsequent implementation of UNIDO's SHP projects in Rwanda.

The 2004 study provided short descriptions of two potential SHP sites in Mutobo and Nyamyotsi. For both sites the consultant had collected socio-economic data by using a questionnaire. However, the study did not include detailed topographical analysis or flow measurements. Instead, the physical data of the site were apparently derived from existing documents and estimations. As a result, the information for each of the sites was quite limited and cost estimates were rather "rough and ready". Thus, qualifying this study as a "feasibility study" would be misleading.

Subsequently, the site characteristics shown in Table 8.2 became the basis for designing the SHP plants in Mutobo and Nyamyotsi I and the text of the 2004 study became the technical annex of the project documents and subcontracts.

Table 8.2 Characteristics of the first two SHP sites as identified in 2004

Name	Households	Capacity	Cost estimations (USD		
			Electro-mechanical equipment	Transmission & distribution lines	Total cost
Mutobo	250	70 kW	81.666	61.000	147.000
Nyamyotsi I	700	75 kW	26.667	84.482	116.082

Source: Feasibility study

8.3. The SHP pilot site of Nyamyotsi I

Based on the information collected in the 2004 study, the SHP pilot plant in Nyamyotsi I was constructed under the UNIDO funded project XPRWA05002. The project document repeats the information on the two sites of Mutobo and Nyamyotsi collected in 2004, although with slightly increased amounts of investment. The project document mentions also Gatubwe as a potential third site, although with less detail than for the other two sites.

8.3.1. Planning of Nyamyotsi I

The project document mentions nine outputs distributed over two phases. Phase 1 (six months) was designed to cover the construction of the pilot site and the preparation of feasibility studies for two other sites. The planning for phase 2 (twelve months) included the identification of 10 additional sites, the preparation of "bankable documents" for each of these sites using sophisticated digital analysis tools as well as outlining a range of capacity building activities. The cost of phase 1 was estimated at 290.000 USD and the cost of phase 2 at 1.363.700 USD. In May 2005, the UNIDO management allocated UNIDO funds of about 200.000 USD for a slightly modified form of phase 1. Several months later, this amount was increased by another 50.000 USD.

The project document explicitly envisaged a "South-South" technology transfer approach. In line with this approach, UNIDO launched a call for tenders among a number of organizations from developing countries specializing in SHP construction and, eventually, selected ENCO Private Ltd. from Sri Lanka as a subcontractor for the construction of the pilot plant in Nyamyotsi I.

8.3.2. The implementation of Nyamyotsi I

The UNIDO subcontractor ENCO started the construction works for Nyamyotsi I in January 2006. The population of the village participated in the construction works, although their voluntary contributions remained below the expectations of the subcontractor who, based on its experiences in Sri Lanka, had expected a greater amount of "sweat equity". The supervision of the construction works was delegated to the SHP specialist who carried out the identification studies in 2004. This expert holds the post of a chairman and managing director of the group of companies to which ENCO belongs.

During the course of the construction works, the hydrological potential of the site was found to be considerably higher than initially estimated. In order to avoid equipping the site below its potential, the Minister asked for a major modification of the design, which UNIDO accepted in April 2006. The length of the penstock was increased and the powerhouse removed to a lower position. Consequently, the theoretically available hydrological power increased from 75 kW to 100 kW, although this power could not be practically reached with the 75kW equipment that had already been ordered before the decision to increase the capacity was made. In September 2006 the subcontractor proceeded to a series of tests and delivered its final report.

In the meantime, however, it became apparent that the silt and sand loads at Nyamyotsi I were considerably higher than anticipated. Quite clearly, the sand load had been underestimated during the feasibility stage of the project. However, it should be mentioned that another feasibility study of the Nyamyotsi I site, carried out in 2005, by two specialized hydraulic engineering companies from the Netherlands and Belgium did also not anticipate that the sand load could become a major problem of this site.

Independently from the question whether the heavy erosion of soil in the catchment area could have been predicted or not, it can be safely stated that the current silt ejection system of Nyamyotsi I is inadequate. As a result, the turbine runner and other silt sensitive parts of the installation have been subject to considerable wear and tear.

On 7 February 2007, the representatives of UNIDO, the Ministry and the subcontractor signed the certificate of acceptance, which also fixed the contractual conditions of the one-year warranty period. Electrogaz, the national electricity utility that is running all electricity distribution systems in Rwanda, was not invited to participate in the commissioning of the installation.

8.3.3. Operation of Nyamyotsi I

The Nyamyotsi I plant serves the village community of Rugera which, in line with the project planning, operates the Nyamyotsi I plant in a self-organized manner. A similar community-based user model is used for comparable SHP plants in Sri Lanka and other Asian countries and the transfer of this user model had been envisaged as part of the "participative and affordable approach to rural energy development" stipulated in the initial 2004 study and in the project document. However, the transfer of this user model met with considerable difficulties.

Since 2006 an elected village electricity committee manages, under the supervision of the village mayor ("executive secretary"), the operation of the SHP plant, the distribution of electricity and the collection of electricity fees. The committee is composed of a president, a vice-president, a secretary and an accountant. A group of nine (!) employed staff ensures the day-to-day operation of the plant. This group is composed of three plant operators, one cleaner, two persons responsible for curing silt and sand from the canal and other parts of the installation, two watchmen and one lady responsible for collecting the fees. The total salaries of this staff are quite considerable (175.000 FR).

Regarding electricity tariffs, the community initially agreed on a system of monthly flat rates ranging from 1.500 FR for individual households up to 10.000 FR for the village health centre and other institutional electricity users. Theoretically, with 183 households being currently connected, this system should ensure a monthly income of more than 300.000 FR, an amount that would correspond to approximately 25% of the monthly income of 2.500 USD predicted in the 2004 study. However, the electricity committees in Rugera experiences considerable problems with collecting even this relatively limited amount of the agreed electricity fees.

One of the difficulties seems to be the flat-rate based tariff system, which turned out to be socially challenging. As a consequence, the committee decided to install electricity meters in every household. At the moment of the evaluation, the distribution system seemed to be in a transient situation, with only 104 out of 183 households being equipped with a meter.

Additional problems arose from power cuts, which became particularly frequent during the rainy season. Reportedly, the necessary curing of silt and sand caused daily power cuts of several hours and also power cuts of several consecutive days. A new attempt to solve the silt and sand problem is currently underway. The tail water of the Nyamyotsi II plant, which is currently under construction upstream, shall be recycled for running Nyamyotsi I. However, a new technical problem occurred in the meantime with a leakage at the lower PVC part of the penstock, appearing in July 2008. At the moment of the evaluation, technical trials for resolving this leakage problem were still underway.

As a result of the accumulating social and technical problems, the number of households paying irregularly, or not at all, is increasing and the collection of fees slows down. Attempts of the committee to cut off non-paying households did not solve the problems but rather aggravated the situation. Allegedly, the staff members who attempted to collect fees and to execute electricity cut-offs came under severe social pressure, to a point where some of them felt threatened. In August 2008, the mayor of Rugera promulgated an ultimatum to the community to reinforce the collection of debts, however with limited success.

There is no evidence that a significant part of the electricity generated by Nyamyotsi I is used for productive purposes. Three battery-charging businesses, several hairdressers and video shops and one small-scale welding workshop have been established, although the equipment of the latter is of rudimentary nature and allows for very basic types of welding only. Attempts to establish an electric grain mill and to equip a woodworking workshop with electrical equipment were abandoned because of technical problems. One of the reasons could be voltage drops due to the low-cost design of the electricity transmission and distribution system in Nyamyotsi I, which does not include medium-voltage transmission and transformers. Voltage records of the mini-grid that would allow verifying this hypothesis are not available.

8.4. The up scaling process: Mutobo, Gatubwe, Nyamyotsi II

On the basis of the Nyamyotsi I pilot site, the Government of Rwanda entrusted UNIDO with a follow-up project. Already in March 2006, six months before the inauguration of Nyamyotsi I, both parties signed a trust fund agreement. The objectives and details of the follow-up project are described in project document SFRWA06001 that became an attachment of the trust fund agreement.

8.4.1. The trust fund agreement between UNIDO and Rwanda

The trust fund agreement mentions 1.2 million USD as an overall budget of the project. The project document SFRWA06001 mentions an additional UNIDO contribution of 130.000 USD but this contribution is not mentioned in the trust fund agreement. The project document sets the duration of the project at 12 months and considers the construction of Nyamyotsi I, which had already occurred with UNIDO funding under project YARWA05001, as phase I of the project SFRWA06001. According to the introductory part of the project document, phase II financed by Government sources would deal with the following:

1. Construct the sites Mutobo and Gatubwe
2. Identify, study and eventually construct a number of mini hydro sites, depending on the specifications and the capacity of the sites considered
3. Capacity building and learning by doing
4. Conceiving an institutional framework for rural energy development

It should be noted that the “number of mini hydro sites” to be constructed under this project is not clearly specified. Table 8.3 extracted from the project document presents, for “the three identified sites” of Mutobo, Nyamyotsi I and Gatubwe, estimated figures for the “project costs” and the monthly income from selling electricity to households and to productive electricity users.

Table 8.3 Estimated project costs of Rwanda sites and projected monthly income (all figures in USD)

	Mutobo	Nyamyotsi I	Gatubwe
Project cost			
Sweat equity	18.000	18.000	27.000
Civil cost	20.000	22.000	45.000
Electro-mech. equipment	55.000	55.000	110.000
Transmission network	25.000	5.000	90.000
Distribution network	40.000	40.000	70.000
Total	**158.000**	**140.000**	**342.000**
Monthly electricity income			
Household lighting (4 USD per month)	1041	1500	2080
Income generating activities	1000	1000	2000
Total	**2041**	**2500**	**4080**

Source: Project document

As for the implementation modalities, the project document SFRWA06001 specified that

- UNIDO would recruit a national project coordinator
- the expert from Sri Lanka already involved in project YARWA05001 would continue to provide the international expertise and to ensure the South-South technology transfer
- MININFRA and KIST would assign at least two engineers and seven staff/graduates to be part of the project team and be trained under the learning-by-doing approach
- implementation would be coordinated and monitored by UNIDO Headquarter staff
- an external evaluation (not budgeted in the project document) “may be conducted” one or two years after project completion

The project document mentions two major risks:

- Hydrological risks because “the longer-term implications of climate change on the rivers in Rwanda cannot be assessed at the moment” (as a strategy to lower this risk the document envisages reducing the capacities to be installed)
- “Time overdraws” are considered “probable” because of the rainy season and other potential sources of delay

Quite confusingly, annex I of the project document describes an “off-grid wind hydro hybrid power project in Arusha” and allocates 205.320 USD to this sub-project. However, this sub-project is not mentioned in the project document itself. Annex II is a true copy of the pre-feasibility study prepared in July 2004 describing the sites of Mutobo and of Nyamyotsi I. The same document had already served as a basis for project YARWA05001 dealing with the construction of Nyamyotsi I. While the annex maintains a capacity of 70 kW for Mutobo it does not mention at all the sites of Gatubwe and Nyamyotsi II.

In July 2006, four months after signature of the trust fund agreement and subsequent to consultations with the Secretary General of MININFRA, both parties agreed to increase the capacity of Mutobo from 70 kW to 200 kW, to maintain Gatubwe at 200 kW and to add Nyamyotsi II as a new site with a capacity of 100 kW. Additional Government funding of 150.000 USD was released for this purpose.

In October 2006 UNIDO and ENCO Private Limited from Sri Lanka, signed a contract for the construction of Mutobo, Gatubwe and Nyamyotsi II. For Mutobo, the contract mentions a capacity of 100 kW, thus not reflecting the agreement of July 2006.

In January 2008, the contract between UNIDO and ENCO became amended, in order to cater for additional anti soil erosion measures, improved de-silting tanks and replacement of the damaged turbine at Nyamyotsi I as well as several technical improvements at the other sites. The interim report from ENCO dated 1st September 2008 provides the following technical specifications and cost estimations for the three sites.

Table 8.4 Technical specifications and costs of Rwanda sites (as-built)

	Mutobo	Gatubwe	Nyamyotsi II
Installed capacity (kW)	200	200	100
Gross head (m)	124	24	115
Generation voltage (V)	400	400	400
Transmission voltage (V)	6600	6600 & 400	400
Distribution voltage (V)	400	400	400
Length of the channel (m)	415	500	24
Length of the penstock (m)	230	35	920
Penstock material	UPVC	Spirally welded steel	UPVC
Turbine type	H-Shaft Turgo Impulse	H-Shaft Francis	H-Shaft Turgo Impulse
Generator type	H-Shaft Brushless	H-Shaft Brushless	H-Shaft Brushless
Main inlet valve	Gate Valve	Butterfly Valve	Gate Valve
Ballast of electronic load Controller (kW)	200	200	100
Cost estimations (USD)	**260.279**	**464.465**	**135.256**

These estimations are significantly higher than the initial estimations (65% for Mutobo and 36% for Gatubwe, see table 7.4).

8.4.2. Status of implementation at Mutobo

At the moment of the evaluation the construction work in Mutobo was almost finished, although not yet commissioned.

The site has been designed without a de-silting tank at intake but, according to ENCO experts, the sand load of the Mutobo river is minimal. Thus, silt problems similar to Nyamyotsi I are unlikely to occur. Significant design differences exist between the technical specifications in the contract and the actual implementation on the ground. While the electrical capacity has been doubled from 100 kW to 200 kW, the transmission voltage has been reduced from 11 kV to 6.6 kV. 150 households are already connected and 80 are still waiting as compared to 350 households foreseen in the contract. In the meantime, the Government asked ENCO, under a separate contract, to set up another load centre with a second transformer. A third load centre could be envisaged in a new compound of 200 recently constructed low-cost houses.

The population of Mutobo impatiently waits for electricity production to start. However, the organizational arrangements still need to be made. At the moment of the evaluation, no management committee had been set up yet, the tariff system had not yet been determined and no decision had been made with regard to a potential implication of Electrogaz into the management and maintenance scheme.

The mayor of the Rwehenderi district, to which Mutobo belongs, is anxious that the 200 kW capacity of Mutobo may not be sufficient in the near future. In this regard it should be borne in mind that the Mutobo minigrid could easily be connected to the national grid, which is at a distance of about 1km, a fact that had not been mentioned in the feasibility study. However, such a connection to the national grid would require conformity of the minigrid with Electrogaz standards, which is currently not yet the case. For example, transformers need to be positioned at least 2 meters above ground. Other conflicts with Electrogaz safety rules may exist. The issue of productive electricity use had not been dealt with in the feasibility study for Mutobo and there are no concrete plans what kind of productive use might be envisaged.

8.4.3. Status of implementation at Gatubwe

Gatubwe is a low-head site. Hence its technical specifications and cost structure are different from Mutobo and Nyamyotsi (see table 8.4). The civil works and installation of electro-mechanical equipment at Gatubwe are well advanced. According to the interim report from ENCO, commissioning is planned for December 2008.

The Gatubwe plant is planned to serve two load centres: a village close to the plant and the village at the border control point with Burundi located at a distance of about 6 km from the plant. Certain parts of the latter village are currently connected on an informal basis to the national electricity grid of Burundi. At none of the two load centres are there concrete plans for productive electricity use. No electricity committee or other organizational structures have been set up yet.

8.4.4. Status of implementation at Nyamyotsi II

The Nyamyotsi II site could not be visited due to time constraints. It is located immediately upstream Nyamyotsi I but it is accessed is by another road. The improvement of this access road has been included in the January 2008 contract amendment with ENCO because the construction of Nyamyotsi II has been delayed by the bad condition of this road.

No feasibility study or construction plans for Nyamyotsi II are available. Major differences exist between the descriptions in the contract and the latest progress report from ENCO. For example, the contract mentions a penstock length of 250 m, while the report mentions 920m. The contract mentions a channel length of

200m, while the report mentions 24 m. Apparently, Nyamyotsi II is planned to serve another village through a separate mini-grid but no information is available on this village. Apparently, an interconnection of the two Nyamyotsi mini-grids is not foreseen. According to the progress report, the construction works at Nyamyotsi II are expected to be finalized in January 2009.

8.4.5. The SHP programme of the Government

The State Minister, who is an RE specialist himself, has launched an ambitious SHP construction program. In January 2008 the Ministry published a comprehensive SHP atlas prepared by a Belgian consulting company based in Kigali and financially supported by the Belgian Cooperation. This atlas describes, in detail more than 300 potential SHP sites throughout the country and confirmed Rwanda's considerable SHP potential, which is one of the most significant in East Africa.

Besides taking up the technological challenges, the SHP program is also exploring possible business models by which the newly built MHP plants could be run in the future. The Dutch Cooperation and GTZ are major partners in this area with a joint program on Public Private Partnerships (PPP) for SHP construction and management. Five privately owned SHP plants are currently under construction with subsidies from the Dutch-German program.

Table 8.5 Rwanda sites currently under construction under the direct contract between Government and ENCO

	Nishili	Janja	Nyirabu-hombo	Nyaba-hanga	Ruhwa	Gashashi	Rugezi	Mukung-wa II
District	Naya-ruguru	Akere-Gakenke	Nyama-heke	Karongi	Rusizi	Rutsiro	Burera	Ruhengeri
Project type	Off grid						Grid connected	
Installed Capacity	400kW	200kW	500kW	200kW	150kW	200kW	2200kW	2500kW
Design flow	1.5m3/s	0.36m3/s	1.0m3/s	0.65m3/s	3.5m3/s	2.3m3/s	2.3m3/s	10.7m3/s
Gross head	48m	82m	85m	47m	7.5	112m	142m	34m
Channel length	210m	785m	905m	240m	350m	-	140m	-
Penstock length	85m	240m	245m	145m	25m	380m	345m	290m

Source: ENCO website

The most significant move of the national SHP programme has been the decision of the Government in 2007 to conclude a wide-ranging contract with ENCO, for the construction of eight additional SHP sites (see table 8.5).

To date, UNIDO has been directly involved in the construction of four SHP plants in Rwanda, which raises the Organization at the rank of the most important partner of the SHP construction programme. It is expected that, by the end of 2009, twelve new MHP plants will be operational. A further expansion of the MHP construction programme is underway.

A number of companies from Sri Lanka and China have entered the Rwanda market since 2005. The Indian bilateral cooperation will come in soon and construct Rwanda's biggest hydro-power scheme. It is expected that this 20 MW plant, together with the SHP program, will help the country bring down its electricity costs, which are currently among the highest in East Africa.

The next step of strengthening Rwanda's energy policy will be the creation of a new National Energy Agency, envisaged to be launched before the end of 2009. This Agency will allow an even better calibration of policy functions. The aim is strengthening the policy making function at the Ministry while the conducting of projects and programmes will be transferred to the Agency.

8.5. Assessment of UNIDO's SHP activities in Rwanda

UNIDO's SHP activities in Rwanda came primarily under the UNIDO financed pilot project at Nyamyotsi I and the Government funded up scaling project SFRWA06001 at the sites of Mutobo, Gatubwe and Nyamyotsi II.

The immediate objective of the project SFRWA06001 has been to:

> *"Demonstrate a participative and affordable approach to rural energy development, through constructing mini-hydro sites in the locations where feasibility studies have been prepared. The process is to be used also for on-the-job training and learning-by-doing. The project will also assist Rwanda in formulating its rural energy strategy, institutional framework and financial mechanisms"*

The project document defined the following five expected outputs:

(i) Constructed pilot site while strengthening the technical capacities of a core team of multidisciplinary national experts
(ii) Completing the studies done for pilot sites and prepare the bankable documents (business plan and implementation plan including procurement documents) and construction of the demonstration sites
(iii) Institutional framework and financial mechanisms for promoting rural energy

(iv) Strengthened awareness among national stakeholders implicated in rural development issues on their role and responsibilities towards facilitating technical and financial inputs in order to promote the involvement of energy service enterprises (developers from private sector and village communities) and partnerships in rural energy development

(v) A final workshop for presenting the final report and validating outcomes

8.5.1. Relevance

The recently published SHP atlas prepared by the Belgian cooperation demonstrated that Rwanda's SHP potential is one of the most significant in East Africa. The atlas data support the aggressive rural electrification and SHP development policies of the Government. There is no doubt that, under such positive framework conditions, the UNIDO pilot project in Nyamyotsi I and the subsequent scaling up project at three additional SHP sites have been highly relevant. However, in order to maximize relevance, the scope of SHP should not be limited to off-grid schemes.

8.5.2. Effectiveness

Effectiveness is defined as *"the extent to which the development intervention's objectives were achieved, or are expected to be achieved, taking into account their relative importance".*

In the present case, the intervention pursued a number of different objectives which, however, were not defined in a very precise and verifiable manner. The following objectives appear, explicitly or implicitly, in the project documents. They have been achieved to variable degrees. Thus, the effectiveness of the project varies depending on the objective considered.

<u>Construction of pilot sites</u>

This objective has been reached at a high degree and above expectations. Four SHP sites, instead of three as initially foreseen, have been developed, which is a remarkable achievement. At the first demonstration site of Nyamyotsi I a number of construction shortcomings were encountered, such as the poor silt ejection system and the penstock leakages. However, such initial weaknesses may be acceptable, at least when considering the "low-cost and learning-by-doing approach" agreed upon between the Government and UNIDO. This approach may also be quoted as a reason behind the fact that, in general, the quality of the planning and reporting documents on the pilot sites has been below state-of-the-art.

<u>Feasibility studies</u>

The low-cost and ad-hoc approach applied under this project entailed a number of technical weaknesses. The initial identification studies were not followed by actual feasibility studies. None of the initially envisaged digital topographic analysis and flow measurements were carried out. The project did not carry out hydrological measurements and hence it cannot be excluded that some of the sites have been equipped below capacity. Site potentials and construction costs were underestimated and hence serious design problems encountered. At the Nyamyotsi I site the design capacity had to be increased leading to prolongation of the penstock and reconstruction of the power house during construction works. Similarly, the capacity of the Mutobo site has been underestimated and provisions doubled after signature of the contract. No concrete plans for developing the productive use of electricity were made. The socio-economic feasibility of transferring the community based user model from Sri Lanka to Rwanda was not analyzed but taken for granted, although the difficulties of applying this model are well-known.

Awareness creation and capacity building

The "on-the-job training and learning-by-doing" philosophy of the project has produced mixed results. The participation of government officials from different ministries in the identification mission created awareness but none of the participants acquired sufficient knowledge to conduct SHP feasibility studies or to oversee SHP construction works. Similarly, a number of local engineers who participated in parts of the SHP construction acquired some basic understanding of SHP construction but none of them would be able to independently design SHP plants or supervise the construction of such plants. However, one of these engineers has set up a consulting office for SHP and is planning to set up a workshop for the provision of SHP maintenance services. The construction workers and technicians who participated in the civil works have acquired considerable practical experience.

Assisting the Government with strategy development

The initially planned Government assistance with regard to strategy development materialized only to a limited extent. An expert from Sri Lanka visited the country and gave a presentation but the Government did never receive his report or any kind of targeted assistance for strategy development.

8.5.3. Efficiency

It seems that the implementation of the project has been guided by the application of a low-cost approach as an overriding principle.

The project has been implemented from UNIDO Headquarters without a national project coordinator. This approach was not in line with the implementation approach envisaged in the project document.

There was no clear attribution of responsibilities as regards the supervision of the construction works. Two staff members of the Ministry were apparently expected to ensure some kind of follow-up and received limited funding from UNIDO for this purpose. In parallel, the same international expert who ascertained some supervision had already carried out the identification studies and who belongs to the same group of companies from Sri Lanka that was subcontracted for the construction and the purchasing of the equipment.

This supervising expert visited the country and the construction sites occasionally but there is no evidence that the quality of construction work and the quality of building materials have been subject to continuous on-site supervision. This procedure is not in line with international good practices and may have contributed to some of the technical weaknesses, mentioned above. However, the procedure reflects the low-cost ("affordable") approach adopted under the UNIDO intervention and which was the shared philosophy when the project was launched. In the meantime, the Government changed this practice by contracting a consulting company from China as an independent technical supervisor. Quite clearly, this more stringent supervision approach will increase quality but also cost.

Project planning and reporting were not in line with UNIDO standards. Information given in the project documents is inconsistent, outputs are vaguely defined and verifiable indicators are lacking. Thus, these documents provide only a poor basis for monitoring and evaluation. The internal UNIDO quality control system did not prevent these weaknesses, probably because the project was considered part of the Integrated Program and hence not subject to proper quality control procedures.

The project duration of 12 months assumed in the project document SFRWA06001 was unrealistic and will be exceeded by at least 15 months. There are many external reasons for these delays, including the fact that the construction company became, in a way, overwhelmed by its own success, and because the Government contracted the same company for constructing eight more SHP plants.

The contracts between UNIDO and the construction company and the international supervisor mention numerous written deliverables such as specifications; plans; draft test reports; final testing and commissioning reports; case studies on each site; papers on the approach used for rural development; etc. Some of these deliverables may exist as internal documents but UNIDO did not establish a proper reporting system with the Government and did not provide the Government with feasibility studies, bankable documents, business and implementation plans including procurement documents and construction plans of the demonstration sites although such documents were mentioned as project outputs in the project document.

As a result of these reporting weaknesses, the government cannot build its assessment of the cooperation with UNIDO on written evidence nor is it in a position to provide donors, investors or other stakeholders with information and lessons learned that would potentially be highly informative and beneficial for further developing the national SHP program. At the end of 2007, UNIDO organized a workshop in Kigali as requested in the project document. However, not all relevant stakeholders were invited and no proceedings or reports on UNIDO's SHP activities in Rwanda were made available on this occasion.

8.5.4. Impact

The impact of the project is variable. Impact on SHP development has been considerable and beyond expectations. However, the *developmental* impact at the pilot site of Nyamyotsi I (the only operational site at the time of the evaluation) is still quite limited.

Impact on SHP development

To date, UNIDO has been involved in the construction of four SHP plants in Rwanda, which raises the Organization at the rank of the most important partner of the SHP construction program. It is expected that, by the end of 2009, twelve new MHP plants will be operational. A further expansion of the MHP construction program is underway.

Through its SHP activities in Rwanda UNIDO demonstrated that an "affordable" approach to SHP construction is indeed possible. By applying its South-South approach to technology transfer UNIDO has brought a SHP construction company from Sri Lanka to Rwanda, thus revolutionizing the local market for SHP consultation and construction services. This success encouraged the Government of Rwanda to expand its SHP program by using the same contractor from Sri Lanka for constructing SHP plants for another 8 sites. In the meantime, the ambitious SHP program of the Government has gained considerable momentum and attracted significant interest from other donors (GTZ; Belgian Cooperation; EU).

With UNIDO assistance, the Government opened up the market of SHP consultancy and construction services in Rwanda, which had until recently been dominated by Western companies. When planning the strategic orientation of the UNIDO intervention, the Ministry and UNIDO made the decision to adopt a South-South technology transfer approach and to combine the planning and construction of the demonstration plant with building national and local capacity in a "learning by doing" approach. This approach was pursued in several stages: Identification of a SHP construction company from Sri Lanka; construction of a SHP pilot plant financed by UNIDO; installation of three additional SHPs by the same company under a trust fund agreement between the Government and UNIDO; direct contract of the Government with the SHP construction company introduced by UNIDO.

Developmental impact at the pilot site

The developmental impact of the project at the first pilot site is currently limited to electric lighting to more than 180 households and to the village health station. The quality of this service is reduced by certain reliability problems.

At the moment, only a very limited share of the electricity produced at Nyamyotsi I is being used for productive purposes, although the productive use of electricity is the main rationale for UNIDO's presence in the SHP field. The identification studies had mentioned several theoretical possibilities of productive uses, such as milling, welding and wood working. The only productive uses that were observed during the evaluation were two commercial battery loading stations and a (very rudimentary) welding post. There were attempts to set up an electrical mill and a wood working workshop but none of them has materialized yet on a sustainable basis, mainly due to technical problems.

The project experience bolsters empirical evidence that significant productive activities do not develop spontaneously simply because of a newly gained access to electricity. This finding is in line with the experience from other SHP projects and rural electrification programs.

8.5.5. Sustainability

The community based business model applied in Nyamyotsi I encounters significant management problems. The applied electricity tariffs are below costs and the theoretical monthly income resulting from applying the agreed tariffs would be only 25% of the monthly income of 2.500 USD envisaged in the initial studies. However, in practice, the electricity committee is currently unable to ensure the collection of even these reduced fees. This leads to a situation where the technical operation and maintenance and hence the economic sustainability of the site are not secured. The managerial difficulties encountered are rather typical for community based or cooperative models and there is no evidence that a private sector based management scheme will lead to more conclusive results because, in Rwanda, there are no such schemes in operation yet. However, it appears that UNIDO and the government relied on the hypothesis that the community based model applied in Sri Lanka would be transferable without major difficulties. Hence they did not yet analyze in depth the wide range of relevant experience with “electricity cooperatives” of different kinds from other countries. This has lead to a situation where the management model still needs to be defined for the 12 new SHP plants in Rwanda that are either already operational or will become available in 2009. There is an urgent need for UNIDO and the Government to focus on these SHP management aspects.

9

The UNIDO SHP Project in Tanzania

Between 2004 and 2006 UNIDO pursued SHP related activities in Tanzania. A 9 kW SHP demonstration plant was constructed in the village of Kinko in the Tanga region. Equipment for a 75 kW SHP plant was donated by the International Hydropower Centre in China but not installed.

9.1 SHP planning and reporting under the IP Tanzania (phase II)

The SHP related activities in Tanzania were implemented on an ad-hoc basis. The IP document for the second phase of the IP Tanzania (2003 – 2006) did not include SHP and no other document defining a UNIDO strategy for SHP development in Tanzania could be identified.

Although SHP was not included in the IP, all IP progress reports include a paragraph on SHP activities. The report of September 2004 mentions the collection of hydrological data at the Sumbawanga site. The progress reports of May and October 2005 mention a 75 kW SHP station to be installed at Yogoma in the Tanga region. The IP report of October 2006 mentions that the Community Center in Sumbawanga has been equipped with "TV, VCR, satellite dish and solar panels" and reports, for the first time, on the establishment of a 9 kW SHP in the village of Kinko in the Tanga region. Under "impact" the same report mentions that for Kinko "3 PCs and productive use". The IP progress reports for 2007 and 2008 repeated the same message. No other SHP related planning documents or reports could be identified at UNIDO Head Quarters.

9.2 Ad-hoc initiation of SHP activities through a visit from China

UNIDO's SHP related activities in Tanzania originated from a visit of a delegation from the Chinese International Hydropower Centre (INHSP), which took place in 2004. On the occasion of this visit a Memorandum of Understanding between INHSP and the Government of Tanzania was discussed, and the donation of equipment for five SHP installations, as well as technical assistance from the Centre and study tours for Tanzanian experts to China.

Although the MoU was not signed, the Government of Tanzania and TANESCO submitted a list of five potential sites. During a second visit the Chinese experts selected the Sumbawanga site in Southern Tanzania from this list and initiated the donation of the necessary equipment for a 75 kW installation at this site. However, the subsequent in-depth hydrological analysis revealed that the Sumbawanga site was inappropriate for SHP installation, among other reasons because of competing water usage for irrigation purposes. To avoid further frustration of the target group at the Sumbawanga site, who had already received several expert visits, UNIDO decided to alternatively equip this site with a solar powered community centre.

9.3 The SHP pilot site of Yongoma

The 75 kW SHP equipment foreseen for Sumbawanga was donated to TANESCO who embarked on identifying a new site that would be an alternative to Sumbawanga but still appropriate for being equipped with the donated equipment. Site visits by a TANESCO team eventually led to the identification of the Yongoma site, in November 2005. However, similar to Sumbawanga, water resources at this site were already being exploited for irrigation purposes and, in addition, for sisal treatment by a sisal estate. The TANESCO experts concluded that, as a result of these competing water usages, a possible SHP plant on this site could only be operated for nine months per year.

On the basis of these findings, TANESCO postponed the decision on Yongoma and entered into negotiations with the owners of the sisal estate and the village community. Another, more in-depth feasibility study carried out by TANESCO in 2007 concluded that, despite the limited water resources, an installation of the 75 kW equipment on the Yongoma site would be economically viable under the condition of a connection to the national grid. The study concluded that *"input from INHSP and UNIDO on the final design will be required, including training of TANESCO experts during detailed design, as per the initial arrangement between UNIDO and INHSP."* Since issuing this study in August 2007 neither the Ministry of Energy nor TANESCO informed UNIDO about these findings and no official request for assistance has been expressed to date.

9.4 The SHP pilot site of Kinko

In order to satisfy the expectations raised by the visits of the Chinese hydropower experts despite the difficulties and delays encountered at the Sumbawanga and Yongoma sites, UNIDO decided to venture into another SHP activity on its own. To this end, three tranches of seed money of a total amount of about 50.000 USD were released for SHP development, although the IP planning document did not include an SHP component.

In May 2005 UNIDO contracted an SHP expert from India who, together with a team from the Tanzanian NGO TaTEDO, carried out an analysis of five pre-identified SHP sites in the Usambara Mountains. Because of time constraints the SHP expert could not visit all sites. In his report he mentions that villagers where not informed about the visit and no preparatory ground work had been carried out. On the basis of rough estimations (the mission took place during the rainy season) the potential of the five sites was assessed between 9 kW (Kinko) and 75 kW (Vuga). According to the report, substantial information was collected only for Vuga. An opportunity to upgrade an existing watermill in Kishwani for electricity generation was discussed but not retained.

Although the report identified Vuga as the most promising location it recommended Kinko as SHP demonstration site. However, the report does not present the selection criteria for this decision. It appears that Kinko was primarily selected because of its very small size and, hence, the limited amount of investment required, which the expert estimated at about 50.000 USD. Approximately the same amount had been made available as UNIDO seed money. In December 2005, UNIDO and TaTEDO signed a Memorandum of Understanding with a view to setting up an SHP demonstration plant in Kinko.

9.4.1. The village of Kinko

Kinko is a village in the Usambara mountains in north-western Tanzania about 440 km from Dar es Salaam. The village is located 29 km from the district capital Lushoto and 7 km from the ward capital of Lukozi, which is connected to the national grid. The village is accessible by a dust road and composed of 9 hamlets that are scattered around a hilly area of about 6 square kms, on both sides of the Kwendurumo River. At the time of the latest available census, in 2002, Kinko had 811 households and 3010 habitants. Presumably these figures have increased since. At the village centre there are 6 churches, two mosques, a couple of small bars and shops, one tailor, several carpenters, a motor mill as well as the village office and the school.

There are two rainy seasons in northwestern Tanzania with the heavy rains occurring between March and mid June and some lighter intermittent rains in December and January. The dry season lasts about four months from August to November.

Kinko is an agricultural village with very little non-agricultural income. Agriculture depends to a large extent on irrigation from the Kwendurumo River. Water is shared through a shift arrangement between Kinko and its neighboring village Mzirangebei. This arrangement is supervised by two representatives from each village. Irrigation is absolutely vital for both villages and there is also a tradition of self-organized irrigation groups. Major agricultural products are maize, potatoes, vegetables and sugar cane.

The educational infrastructure in Kinko is relatively well developed. The first primary school in Kinko dates back to 1972 and a second primary school was established in 2003. However, no health infrastructure exists in the village. The nearest dispensary is 5 km away and this centre is not connected to the national grid.

The community does not have access to clean and safe water supply. The baseline report prepared by TaTEDO in February 2006 points out that “the health situation of most people in the village is not good which limits their availability and capability in productive activities.” Drinking water is obtained from streams and canals, leading to “frequent stomach problems, diarrhea and typhoid disease outbreaks.” The report also mentions that drinking water is polluted by chemical fertilizers and insecticides and concludes that “this will in the long run bring about serious health hazards to the community” unless water supply will be improved.

Household energy consumption in Kinko consists mainly of wood and other biomass for cooking and of kerosene for lighting purposes. The baseline study estimated that a household spends about 1800 TSh per month on kerosene. People interviewed during the evaluation estimated this amount to be as high as 4000 TSh. The number of mobile telephone in the village is estimated to be around 30.

9.4.2. Small-scale agricultural processing activities in Kinko

The only significant commercial agricultural processing in Kinko are maize milling and sugar cane crushing. There is one maize mill, which is reported to be working primarily during those parts of the year, where locally produced maize is available. During the rest of the year, Kinko villagers would buy their maize in Lukozi and use a mill there. The milling prize in Lukozi is reported to be less than half of the price in Kinko, which can be explained by the fact that the Lukuzi mill is an electrical mill connected to the grid while the Kinko mill is powered by a diesel engine. The baseline report mentions two maize mills in Kinko but, at the moment of the evaluation mission, only one of them was left. The other miller had apparently abandoned its business and sold its equipment to a third person who brought the mill to his compound in the village centre. It appears that motor milling is not a very profitable business in Kinko because of limited demand and high energy prices.

The second agro-business in Kinko consists of alcohol production from sugar cane and seems to be more profitable. There are six manual sugar cane crushers in Kinko producing sugar cane juice, which is subsequently transformed to alcohol using traditional processes. Although the socio-economics of this production have not been studied yet it appears that alcohol production represents a major source of income also for women. Local authorities are pre-occupied with what they consider a quite massive production of alcohol and the sanitary risks, which this trade represents for Kinko and the surrounding villages. Under these circumstances, increasing the production of alcohol trough mechanization would be perceived as a threat rather than an opportunity.

9.4.3 Design, construction and commissioning of the SHP plant in Kinko

The plant was designed by the UNIDO SHP consultant from India, who also flew in from time to time to supervise progress and install the major mechanical and electrical equipment. Another consultant from India was called upon by UNIDO to supervise some of the civil works. No reports from these assignments or records on their effective on-site presence could be made available to the evaluator. Most of the supervision and management of the construction was carried out by a local consultant from TaTEDO, who prepared three progress reports on the construction of the plant.

Plant construction occurred between December 2005 and the inauguration of the plant by the Minister of Energy and Mining on 21 September 2006. All civil works were conducted using local and village labor and without mechanical equipment, which is a major technical achievement. Nevertheless, the construction approach was influenced quite heavily by the limited financial resources. UNIDO managed to overcome some of these limitations through mobilizing construction material as voluntary contributions from the local administration and from a major Tanzanian cement manufacturer, which is another remarkable achievement.

However, the financial shortages did affect the quality of the civil works in a number of respects, such as the limited height and resistance of the canal walls (brick walls partly without plastering) and the absence of canal covering slabs and screw gates for removing silt from the pond. Quite clearly, these construction shortcomings had negative effects on plant operation.

Setting up the electricity distribution system was subcontracted through a local tendering process to a specialized company located in Lushoto. No major problems or delays occurred during installation with the exception of cost increases due to the unexpected need to apply strict TANESCO norms on electricity poles and other material.[32]

The SHP demonstration plant in Kinko

The checking dam is an impressive structure of about 40m long and 2m high. It retains the Kwendurumo River and forms a storage pond of an estimated surface of about 4000 m^2. To allow for the evacuation of silt from the pond the dam is equipped with two small flush gates closed by two rudimentary wooden plates. The intake is controlled by an iron tube valve leading to a small de-silting tank of about 10 m^2 and a depth of 0.5 m below the bottom of the canal. The evacuation of the de-silting tank occurs through a 20 cm steel pipe closed by a bolted metal cover, which is not easy to remove. The canal is about 60cm wide and 55cm high and follows on a length of 500m the left bank slope of the river down to the fore bay with its spillway. Building the canal required several major efforts such as blasting rocks and building bridges.

The penstock is made out of locally available PVC pipes. The powerhouse houses the sluice control valve, the sluice bypass valve, the turbine (reverse pump type), the generator and the electronic load controller. All this equipment has been imported from India.

A 415V triphase 1.3km long transmission line leads to the village center from where 220V monophase electricity is distributed to the community centre and to the houses. According to the completion report of the electricity contractor 100 houses have been wired and 80 of them are connected to the minigrid. Thus electricity access is limited to the population of the village centre (about 20% of the total population). Standard house wiring consists of two lighting points

[32] In a message to UNIDO in May 2006 the contractor attracted UNIDO’s attention to the following: “The erection of the poles and stringing of the overhead conductor is according to TANESCO’s regulations as per engineering instruction to British standards. Registered electrical contractors are to adhere to these instructions. If you later need TANESCO to provide technical support then you have to construct the low volt line according to their regulations. You can’t simply use ordinary forest poles that are not treated or without the required length and size.”

equipped with low-energy bulbs of 11W each and one plug. Protection is by clusters of ten houses using 6 Amp miniature switches.

The so-called “community centre” has been set up in a small room of the school of about 10 $m^{2.}$ This room houses two computers as well as a satellite TV set. Five plugs for charging mobile phones are available in the same room. During football championships the TV set is transferred to one of the bigger classrooms.

9.4.4 Operation of the Kinko plant

The only monitoring report available is the one prepared by the TaTEDO consultant at the end of December 2006, about three months after the inauguration of the plant. No continuous monitoring system is in place that would have allowed recording the operation days, the number of operation hours and the maintenance of the plant. Hence the impossibility to come up with reliable information on plant operation and maintenance and the amount of energy produced over the 24 months since the inauguration of the plant. The following qualitative information is based on interviews with the local UNIDO consultant, one of the operators and the headmaster of the school.

The operation of the plant has been marked by several major interruptions. The first one occurred in December 2006 due to heavy rains washing away parts of the canal walls near the intake and of the fore bay spillway. These damages were repaired apparently without major delays by the villagers themselves using their own means and with the help of the TaTEDO consultant. Another interruption around the same time was caused by over-voltage, destroying the lamps in part of the village network. It seems that this incident was caused by poor protection measures implemented by the company subcontracted for the installation of the network. The third interruption occurred around February 2007 when one of the bearings of the turbine became damaged. Again, the village was able to fix the problem without major external assistance by bringing in a mechanic from a neighboring village. Reportedly, the necessary amount of about 50.000 TSh was mobilized by the village.

The forth and most damaging interruption occurred in May 2008. It was caused by an accumulation of silt in the penstock, which gradually obstructed the flow of water and the operation of the sluice valves. When the turbine eventually came to a total standstill the plant operators tried to fix the problem by disconnecting the penstock from the valves. This operation was successful as far as it allowed evacuating the silt from the penstock. However, it caused an inundation of the powerhouse and the generator, damaging the generator due to humidity. This time the village was unable to fix the problem with its own means. They alerted the TaTEDO consultant who dismantled the generator and brought it to Dar es Salaam for rewinding. Overall, this interruption lasted about four months from May to September 2008. Repair costs were born by UNIDO.

In addition to, these major technical problems the operation of the plant has been increasingly limited by the availability of water. Although no written records are available there is no doubt that the number of operating days is much less than theoretically possible. It seems that, during the dry season, the plant does not operate most of the time and, if it operates at all, this would be only for two or three hours per day.

Water shortages have been aggravated because the storage pond was filled almost entirely with mud. Part of its initial surface was being used for cultivation and, apparently, no de-silting of the pond occurred. At the moment of the evaluation, interviewees recognized that operating the plant for at least some hours per day would require periodical de-silting. In the absence of such basic maintenance work the operation of the plant seems to have come down to a very limited number of hours only.

Lighting has been the main and almost exclusive use of the small amount of electrical energy available. To satisfy this demand, the plant is being operated, if at all, during evening hours only. Under these conditions it is obvious that no productive use of electricity has been possible. There has been some use of the TV set, in particular during football championships. The use of the computers has been heavily constrained by the fact that the initially envisaged computer training for teachers and other interested persons in the village has not been provided. UNIDO had asked the vocational training centre VETA in Tanga to provide such services but this idea did not materialize.

The initial objective of using the electricity for productive purposes has not been actively pursued.

9.4.5 The management structure in Kinko

The initially foreseen management structure comprised a General Council, a Technical Committee, a Financial Committee, an Administrative Committee and an Executive Committee. One representatives from each electrified house, as well as representatives from UNIDO, TaTEDO, TANESCO, the District Office and the Village Office were supposed to participate in these committees.

Quite clearly, this complicated and heavy structure was inappropriate and impossible to implement. It seems that, in practice, a committee of 10 members has been elected, with the school headmaster acting both as a secretary and a treasurer. This committee seems to have met a few times at the beginning of the project but, since more than one year, no formal meetings seem to have occurred.

Initially the tariff for delivering electricity to each of the connected houses was fixed at a very low level of 1.500 TSh per month, an amount that would be less than half of the reported expenses for kerosene. Due to the interruptions of service a regular and continuous collection of money did never occur. It seems that, in the past, the necessary repairs have been financed by voluntary contributions from some of the more well-off members of the community.

9.4.6 Challenges

The project has encountered a number of challenges. Most of these challenges relate to risks that had already been identified during the preparation stages of the project.

The TaTEDO baseline study prepared in December 2006 points out that "far ahead of power generation, the village needs social services such as health services and clean drinking water". A SWOT analysis at the end of the report mentions the following "weaknesses in relation to the project intervention":

- Low level of education of the majority of the community could restrict the community's management capability
- Low levels of technical know how and entrepreneurship skills could prevent the community from grasping opportunities for income generation that may arise as a result of the project
- Scattered households and hilly topography of the village could complicate power transmission lines and raise respective costs considering the low energy consumption per capita that is typical for most rural communities
- Low power capacity of the micro hydro system to be installed would limit the connection of power intensive appliances, equipment and loads
- Limited water flow during the dry seasons could affect the availability of power during these periods
- Limited market for various products that could benefit from the project intervention such as milk preservation and packaging and hair saloons

Under potential threats the baseline report mentions that:

- Low levels of water during the dry season may result in conflicts of interest between power generation, irrigation and water for livestock
- The fact that the plant will be small to cater for the identified energy demand could cause "vandalism"

The limited availability and conflicting uses of water had been identified as a major risk during the preparation phase of the project. In November 2005 an expert meeting took place at the Ministry of Energy and Minerals under the chairmanship of the Commissioner for Energy. On this occasion it was reported that the water flow in Kinko had not been measured but simply estimated using the "salt dissolution method". This method was found not to be reliable and inappropriate for designing a scheme. The meeting decided that *"a team of experts from TANESCO and MAJI should immediately visit the site and take actual flow measurements using a current meter."*

In early December 2005 a TANESCO water technician carried out spot discharge measurements in Kinko. In her report she mentioned that *"virtually there was no flow"* while assuming that the water flow would improve during the rainy season. The TANESCO report concludes that *"the site was found to be located in a seasonal river and people living along the river use this water for irrigation purposes, which causes the river to dry up."* On the basis of this report TANESCO refrained from participating in the Kinko project but UNIDO and TaTEDO decided to carry on, although there is no evidence in the records of a formal decision to do so.

The project management was also aware of the difficulties to set up an effective management scheme and that such a scheme is a key success factor for such projects. In March 2006 the project coordinator at UNIDO HQ wrote in a mail to the Indian subcontractor that *"there needs to be some sort of cooperative set up at the community level for the running of the power house. TaTEDO should get involved in this and also the local government. If TANESCO can help, that would have been great."* In his reply the consultant agreed and pointed out that *"this is very important. If the present attitude of the villagers continues, the project will fail soon."*

The subcontractor in charge of setting up the electricity distribution system pointed out in a message to UNIDO that, *"to our experience, unless the technicians who will be responsible to run the power house to be serious to control this and people should be educated highly, otherwise we feel all of our efforts to this project will be in problem."*

The project managers were also aware of the fact that, for capacity reasons and because of high electricity distribution costs, it would be impossible to connect more than a limited fraction of the village to the minigrid. UNIDO recognized that this technical limitation would automatically restrict the interest and mobilization potential for the project to those 20% of the village population living in the centre. For this reason a supplementary solar power system with rechargeable lamps was envisaged at a certain stage, which would have allowed lighting services also to unconnected houses. In 2006 UNIDO earmarked an amount of 10.000 USD for this purpose but, probably due to shortages of funding, this idea was abandoned.

9.4.7 Capacity building

Capacity building occurred for a number of aspects. The main partner for capacity building has been TaTEDO, which delegated one of its staff members to supervise the construction of the plant under a subcontract with UNIDO. Subsequently, UNIDO hired this engineer directly. Through his participation in the project during an extended period of almost two years this engineer acquired in-depth knowledge in SHP design and construction. In combination with his recent post-graduate master studies in the Netherlands he is now probably one of the most knowledgeable Tanzanian specialists in this field. However, with the exception of the baseline study, there has only been little participation of other TaTEDO collaborators in the project. There is no evidence of other significant capacity building within TaTEDO.

No capacity building occurred within TANESCO who withdrew from the project at an early stage. The village and district authorities and local government organizations or extension services such as VETO did also not involve themselves in the project to a significant degree.

Several local partners have been involved in the civil works. A local mason was contracted for constructing the check dam and other more complicated parts of the civil works.

As regards the village community itself it is difficult to assess to what extent at least some technical and management capacity has been built. Although it should be noted that the village community managed to overcome some of the technical problems by its own means, it can be safely stated that the technical and management capacities of the community are still far beyond of what is required to run a SHP village plant.

9.5 Assessment of UNIDO’s SHP related activities in Tanzania

UNIDO carried out its SHP related activities in Tanzania as an ad-hoc reaction to a visit of a delegation from the Chinese International Hydropower Centre (INHSP). The activities were initiated without planning documents and hence without an explicit strategy, objectives, expected outcomes and assumptions. The following assessment has, therefore, been based on the generic evaluation questions included in the terms of reference of the SHP programme review.

9.5.1 Relevance

The generic evaluation questions outline five major areas where projects promoting the productive use of electricity generated from SHP sources could make relevant contributions:

- Policies for SHP development
- Institutions and regulatory framework for SHP development
- Knowledge of SHP resources
- Demonstration and transfer of innovative SHP technologies and user models
- Promoting the use of electricity from SHP sources for productive purposes

UNIDO’s SHP related activities in Tanzania were not designed to enhance the SHP related policies, regulatory frameworks or institutions of the country or to improve the knowledge of SHP resources. With regard to the latter, it appears that the availability of such knowledge was taken for granted. However, with the benefit of hindsight, the limited knowledge of SHP resources (flow curves; silt loads; competing uses; etc) turned out to be a major bottleneck.

Table 9.1: Operational SHP sites in Tanzania

No.	Location	Year installed	Installed capacity (kW)	Developer/Owner
1	Tosamaganga (Iringa)	1951	1220	TANESCO
2	Kikuletwa (Moshi)	--	1160	TANESCO
3	Kitai (Songea)	1976	45	Prisons Dept/Government
4	Nyagao (Lindi)	1974	15.8	RC Mission
5	Isoko (Tukuyu)	--	7.3	Mission not specified
6	Uwemba (Njombe)	1971	800	Benedict Fathers
7	Bulongwa (Njombe)	--	180	Mission (not specified)
8	Kaengesa (Sumbawanga)	1967	44	Catholic Mission
9	Rungwe (Tukuyu)	1964	21.2	Moravian Mission
10	Nyagao (Lindi)	--	38.8	Mission (not specified)
11	Peramiho (Songea)	1962	34.6	Benedict Fathers
12	Isoko (Tukuyu)	1973	15.5	Moravian Mission
13	Ndanda (Lindi)	--	14.4	Mission (not specified)
14	Ngaresero (Arusha)	1982	15	M. H Leach
15	Sakare (Soni)	1948	6.3	Benedict Fathers
16	Mbarari (Mbeya)	1972	700	NAFCO/Government
17	Ndolage (Bukoba)	1961	55	Catholic Mission
18	Ikonda (Maketa)	1975	40	Catholic Mission
19	Mbalizi (Mbeya)	1958	340	TANESCO

Source: TANESCO survey

It seems that the project concentrated on the demonstration and transfer of innovative SHP technologies as its main area of relevance. However, SHP technology is not new to Tanzania. Between 1935 and 1972 the British turbine manufacturer Gilkes delivered 20 turbines (3 kW to 900 kW) and between 1967 and 2002 the German turbine supplier Ossberger delivered 22 turbines (7.5 kW to 376 kW). In 1986 a TANESCO survey identified 28 MHP's in the Tanga, Kilimanjaro and Arusha regions (7 operating, 11 non operating, reactivation possible; 10 not operating, reactivation not possible). A recent study lists the 19 operational SHP shown in Table 9.1.

There is little evidence that the technology choice has been based on previous country experience, nor that it has been intended to demonstrate specific innovative or niche technologies. The project promoted Chinese and Indian SHP equipment, which may be justifiable with a view to introducing less costly alternatives to the European providers. However, such a strategy needs to be well founded and broadly based in order to be relevant. A one-shot introduction of a new technology provider is highly problematic with a view to spare parts and maintenance problems.

Because of its design the project has been irrelevant with regard to promoting the productive use of electricity from SHP sources. Upgrading existing watermills with a generator for electricity generation has been a successful strategy in some Asian countries (Nepal, Sri Lanka). Although a similar opportunity had been identified in Tanzania, the project did not pursue this possible demonstration route. Rechargeable LED lamps were not demonstrated, although they are an innovative technology with a high potential for improving the overall feasibility and economics of SHP.

The potentially most relevant design feature of the project has been its attempt to demonstrate an innovative community based user model. However, as will be shown below, the adopted demonstration strategy has been ineffective.

From the point of view of the village population in Kinko the SHP demonstration plant is at best moderately relevant. The decision for Kinko has been motivated by the hydrological properties of the site but does not reflect the natural priorities of the population. Kinko villagers do not have access to clean drinking water nor do they have a health post in the village. As a result, the base-line study reported significant health problems and suggested rethinking priorities.

9.5.2 Effectiveness and efficiency

The project did not reach its objective of demonstrating the productive use of electricity generated from SHP sources. Therefore, a separate assessment of effectiveness and efficiency is not possible. The 75 kW equipment donated from China sits, three years after delivery, still in a warehouse. The 9 kW demonstration plant in Kinko operates only randomly and only for lighting purposes.

The main reasons of this failure are as follows:

- Project was not part of the mutually agreed Integrated Program but triggered by a visit of an INHSP delegation and the subsequent donation of SHP equipment from China

- Decision for the initial 75 kW site was made without proper analysis of water resources

- Not clear why Kinko was planned by an Indian expert and equipped with Indian technology, although the project was initiated with the Chinese centre

- Decision for Kinko as the smallest possible demonstration site because the available UNIDO funds were to limited for a bigger site that would have been more adequate for productive use

- Overestimation of the water resources available at the Kinko site (despite early warning by TANESCO expert)

- Decision to launch Kinko without support from TANESCO or any other locally represented organization or NGO

- Poor design and execution of civil works: silting problems due to poorly designed flush gates and uncovered canal

- Community commitment is undermined because, by design, the scheme can serve only 20% of the potential users (the problem could have overcome by introducing rechargeable lamps; the strategic importance of introducing such lamps had been discussed but abandoned because of lack of funds)

- Inadequate user model (four different committees foreseen, none of them working; application of flat rate tariff without load limiters and meters; no collection of electricity fees)

- There is no logbook and hence no information on electricity production; load curves; down times, etc

- Although possibilities for the productive use of electricity do exist (milling and sugar cane crushing) these options where not investigated nor has the demonstration site been designed accordingly

With a view to demonstrating low-cost SHP technologies, the “pump-for-turbine” solution in Kinko has been a positive decision. However, the decision to import a pump from India is likely to be inefficient because of spare part problems. Because of its heavy exposure to silt the pump runner is likely to be already eroded (no inspection done).

Capacity building has been almost entirely limited to training one member of a local NGO specializing in Renewable Energies.

9.5.3 Sustainability

At the moment, the demonstration site in Kinko is not sustainable because of technical and management problems. Major technical improvements and a different user model would be necessary for achieving sustainability.

9.5.4 Impact

Due to technical and management problems, the generation of SHP electricity in Kinko is unreliable, ephemeral, not sustainable and, therefore, of very limited impact. There is a risk that this site could produce negative demonstration effects, if the technical and management problems are not solved.

The 75 kW equipment donated by China has not yet been installed. However, it seems that the availability of this equipment and the difficulties with identifying an appropriate site has motivated TANESCO to carry out a systematic survey of the hydrological resources for SHP in a number of provinces, which could be considered a major unexpected impact of the project. However, the research for a site that would be appropriate for the available equipment has lead to a supply driven approach. It appears that the hydrological potential of the envisaged Yongoma site would allow for more powerful equipment.

10

The UNIDO SHP project in Kenya

The first phase of the Integrated Programme (IP) in Kenya was carried out between 2003 and 2007 and had a strong focus on agro-industry. The IP planning document envisaged leather, fish, honey, and dairy and women entrepreneurship as main areas. However, only the leather component received substantial external funding. The IP did not include any energy related activities. It was evaluated in 2006 and the second phase of the IP is under development since May 2007.

At the end of 2006, after a long period of vacancy, UNIDO delegated a new Representative (UR) to the UNIDO Field Office in Kenya. Under his previous assignment at Head Quarters the new UR had been responsible for hydro-power and other renewable energies (RE).

During the first half of 2007, the UR submitted a number of project proposals to UNIDO HQ for funding from UNIDO programmable funds. These proposals were related to renewable energies and funding was agreed without delay. At the moment of the evaluation the following RE related projects were ongoing:

Table 10.1: SHP related UNIDO projects in Kenya

Project Nr	Project Title	Allotments[33]	
		Euro	USD
XPKEN07001; YAKEN07008	IMPLEMENTATION OF 10 MODEL PICO HYDRO SYSTEMS IN KENYA (PART OF THE ENERGY COMPONENT OF IP KENYA)	127,500	180,000
XPKEN07003; YAKEN07004	IMPLEMENTATION OF 3 BIOMASS WASTE DIGESTERS IN SELECTED MILLENNIUM DISTRICTS (IN RURAL OFF-GRID AREAS) IN KENYA (PART OF ENERGY COMPONENT OF IP KENYA)	147,000	206,000
XPKEN07005	IMPLEMENTATION OF ENERGY KIOSK POWERED BY STRAIGHT VEGETABLE OIL (SVO) GENERATORS IN 9 SELECTED MILLENNIUM DISTRICTS OF KENYA	147,500	217,000
Total			**603,000**

Source: UNIDO Infobase

[33] UNIDO programmable funds are allotted in euro; transfer in USD was subject to fluctuating exchange rate

By UNIDO standards, the availability of 600,000 USD from UNIDO programmable funds for one country is quite exceptional. The new UR made good use of this budget to revitalize UNIDO's presence and visibility in the country and to start mobilizing donor funds for new RE projects.

However, the funding of these projects from UNIDO programmable funds had also an administrative downside. Because the budget had been drawn from UNIDO's 2006/2007 biannual budget, the amount had to be spent, at least in principle, before the end of 2007. The resulting spending pressure had negative effects on implementation quality, although some delays were accepted by the UNIDO financial service.

10.1 Electrification and renewable energy issues in Kenya

At the moment of this evaluation, the Ministry of Energy was in the process of updating the national energy master plan and expanding this plan to renewable energy sources. To this end, the Ministry used technical assistance from a renowned German energy consultancy firm with financial support from Finland.

The revamp of the energy master plan produced a wealth of information shedding light on the framework conditions of UNIDO's renewable energy activities in Kenya. The information and analysis produced under this process could also become a valuable input into UNIDO's future planning. Some key points that are interesting for the evaluation of the overall orientation and relevance of UNIDO's SHP activities in Kenya are briefly mentioned below.

10.1.1 Rural electrification increases rapidly but from a very low level

Currently, about 1144 MW of the total effective generation capacity in Kenya of 1153 MW is interconnected through the national grid, thereof 58% hydro, 31% thermal and 11% geothermal. The peak power demand within the system observed a continuous increase from 708 MW in 1999/2000 to 987 MW in 2006/2007.

Within the national grid, the Rural Electrification Programme (REP) absorbs some 45 MW of the effective capacity, corresponding to a share of 4%. The isolated effective generation capacity is 9 MW, i.e. 0.8% of the total system capacity. Since 2000 the purchases for the REP increased from approx. 175 GWh to 270 GWh, i.e. by 6.3% p.a., a growth rate that is above national average. The share of the purchases for the REP is 4.4%. This is largely due to the spectacular increase in REP purchases by 31% in 2006/07.

By June 2007 133,047 customers had benefited from the REP. The number of new customers connected per year increased significantly from about 5,000-9,000 p.a. between 1999 and 2006 to over 22,000 p.a. in 2006/2007.

10.1.2 Surprisingly high penetration rate of solar home systems

In 64% of non-electrified localities, diesel power generators are common, and in 65% individual solar home systems. Commercial battery charging shops were found in 14% of the non-electrified locations.

Solar panels were more common in the Central and Mount Kenya and South-Southern Rift Valley regions, where more than one-third of households (35-36%) reportedly own solar home systems for lighting and TV. In other areas, in particular in the poorer areas of North-West and of Nyanza-Western clusters, solar home systems were less frequent, but even there 11-15% of households seem to own solar home systems.

10.1.3 Despite subsidies, many poor households cannot afford grid access

The survey found that 25% of households in non-electrified locations indicated an average income of 5,000 to 10,000 KSh[34] per month, and 27% an income between 10,000 and 20,000 KSh. 28% of the surveyed households fall below the national poverty line of 2,181 KSh. About 5% of households have a monthly income of less than 2,000 KSh and belong to the very poor.

The average connection *cost* per new customer went up from less than KSh 60,000 in 1999/2000 to more than KSh 225,000 in 2006/2007. The house connection *fee* amounts to KSh 32,500 and is thus highly subsidized. However, many rural households cannot afford this fee. The master plan considers that widespread connection to the distribution system in rural areas would require more detailed studies in order to establish a suitable connection fee. Households considered to be eligible for electrification declared themselves ready to pay an average amount of 720 KSh per month and household for electricity.

A recent survey carried out under the “Lighting Africa” initiative of the World Bank confirmed that cost and not proximity to the power line is the main inhibiting factor for households that are lacking access to the grid. For 49 % of households in the sample (66% of traders) the grid is on the street they live or close by. For 31% of the households (19% of the traders) the grid is within 5 kms. Grid expansion plans are not transparent. 57% of consumers do not know of any extension plans and those who know that there is an extension plan are not clear on when the extension is to take place.[35]

10.1.4 Potential customers for productive use of electricity

The survey found that retail shops, small restaurants & food stalls, tailor shops and hair dressing saloons are found in 75% of the non-electrified localities. More than half of these localities have car and bicycle repair shops. Electricity demand

[34] 100 Ksh = 1.30 USD
[35] http://lightingafrica.org

of these businesses is characterized by lighting of commercial shops, small restaurants, service workshops as well as cooling and conservation of drinks and food. Other services such as tailor shops and hair-dressing saloons may have needs for additional electric devices. In general, businesses in the commercial and services sub-sector will not require more than 3 to 5 Amperes.

Productive small-scale and processing industries, which are usually more energy-intensive, are generally less frequently found in the sampled localities. Most widespread are grain ("posho") mills and furniture maker workshops, being represented in more than 75% of the localities. Fairly frequent are also blacksmith workshops with an availability share of 40%. This type of industry is characterized by a higher power demand, often exceeding 5 Amperes.

10.1.5 Policy and institutional environment for rural electrification

The National Energy Policy (NEP) highlights the importance of rural electrification and the encouragement of a wider use of renewable energy technologies, including the promotion of private sector investments in renewable and other off-grid generation. The main orientations of the NEP document of 2004 are considered in the new Energy Act, in force since July 2007. The key elements of the Act are:

- Establishment and empowerment of the Energy Regulatory Commission (ERC)
- Introduction of licenses for electricity production, import and export, transportation and distribution
- Tariff setting and regulation
- Creation of the New Rural Electrification Authority (REA)
- Creation of the Rural Electrification Programme Fund (REPF)

The REA was formally established in July 2007 and the recruitment process of the top management, senior and other professional staff was completed only recently.

Within the mandate of REA, the following issues are considered most important:

- Management of the Rural Electrification Programme Fund
- Development and updating of the Rural Electrification Master Plan
- Implementation and sourcing of more funds for the Rural Electrification Programme
- Promotion of the use of renewable energy sources, including but not limited to small hydropower, wind, solar, biomass, geothermal, hybrid systems and oil-fired components, taking into account specific needs of certain areas, including the potential for using electricity for irrigation and in support of off-farm income generating activities
- Management of the delineation, tendering and award of contracts for licenses and permits for rural electrification

The electricity master plan suggests that REA should focus on:

- Countrywide improved energy access to all rural settlements and their inhabitants, at community and ultimately at household level, and
- Improved productive use of electricity (!)

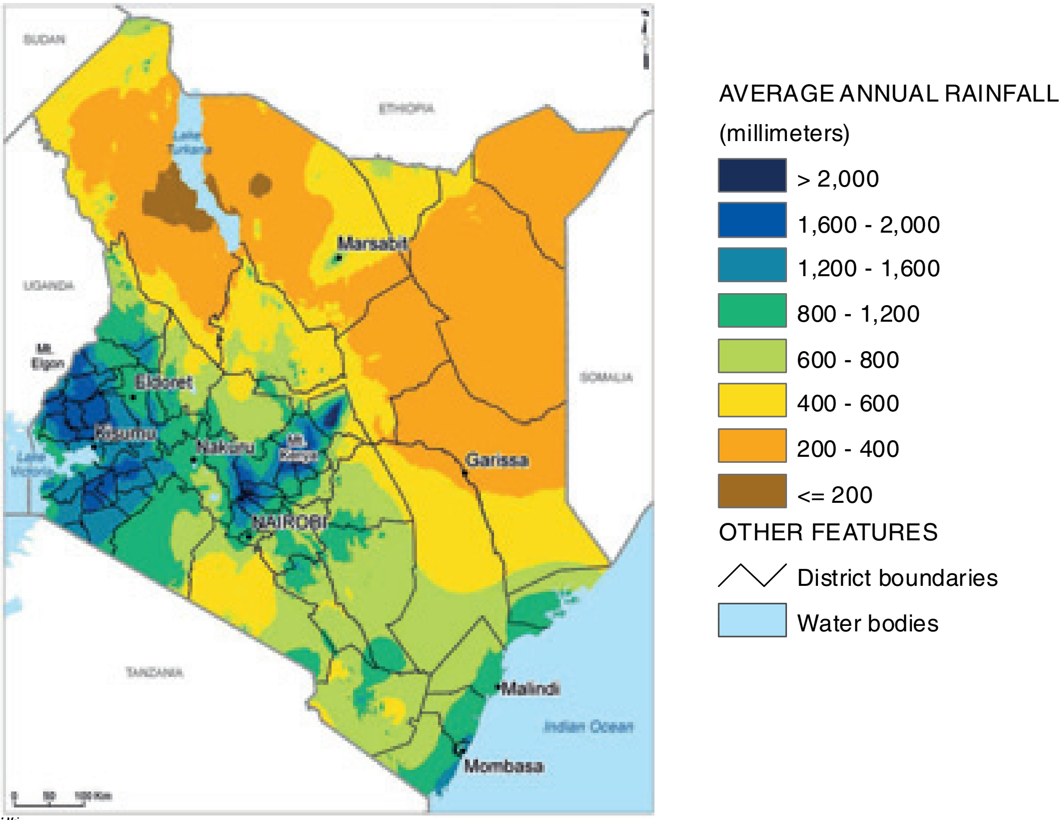
10.2 Kenya’s renewable energy potential under a poverty perspective

Energy and rural electrification are high on the agenda of the Kenyan Government. In recent years, the national electricity facility KPLC has been expanding the electricity grid rather vigorously into the more densely populated parts of rural Kenya, such as the Mount Kenya region and Western Kenya. This rather aggressive grid expansion had also consequences for UNIDO’s SHP activities because the locations of all four pilot sites are either already connected to the grid or at a distance of less than 1 km from the grid.

Kenya’s most densely populated regions are at the same time the most mountainous, the most humid, and the most fertile regions. On the other hand, vast parts of the country are relatively dry, flat, scarcely populated and poor. From the point of view of promoting SHP technologies this geographic situation leads to a certain strategic dilemma because the poorest and most remote parts of the country can hardly be reached by SHP technology.

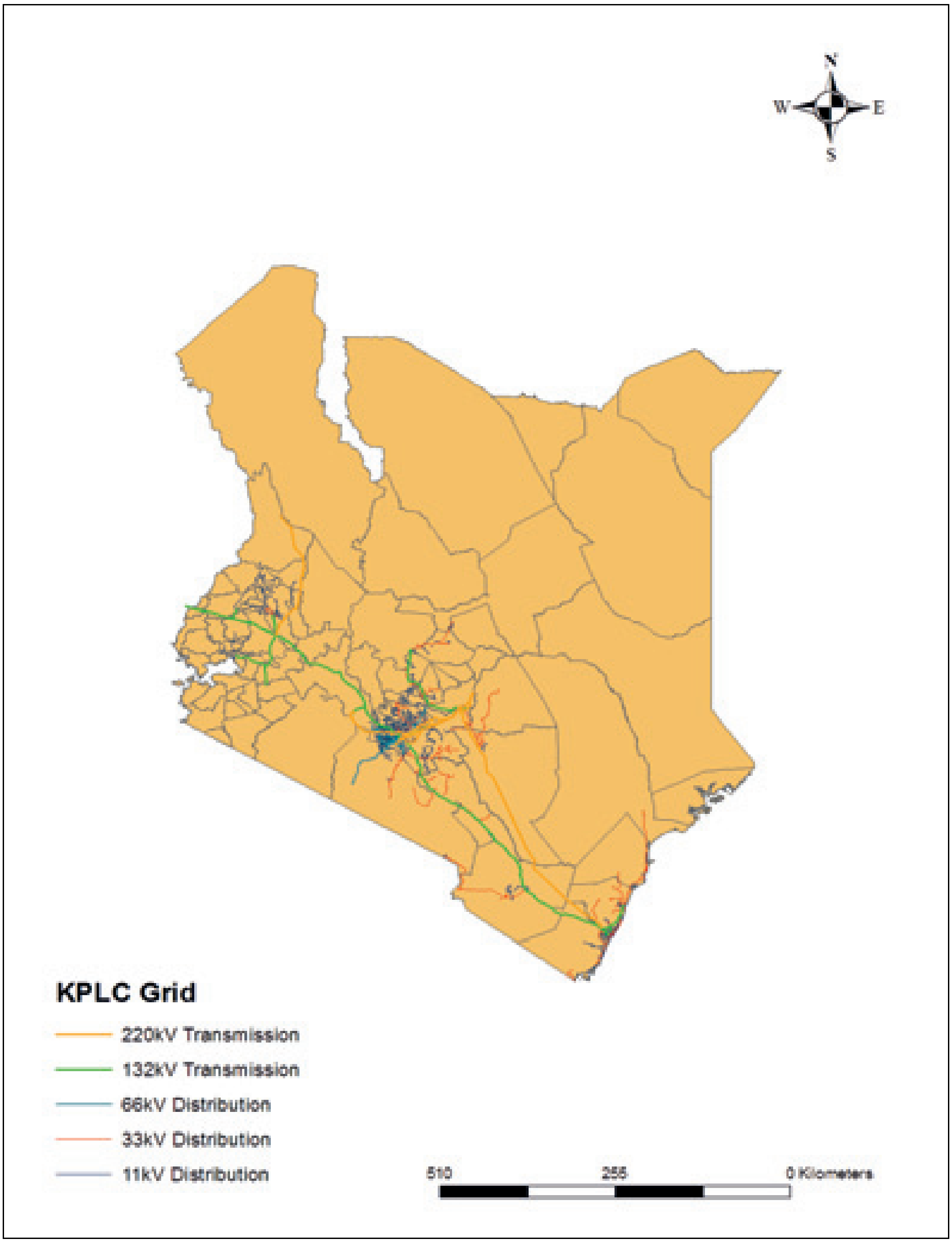
This dilemma seems to be similar in other countries. Because, for the Kenyan case, the recently published “poverty atlas” provides an excellent analysis of the critical parameters, the relevant maps from the “poverty atlas” are documented below.[36]

Map 1: Average annual rainfall in Kenya



[36] Nature's Benefits in Kenya: An Atlas of Ecosystems and Human Well-Being; World Resources Institute; May 2007; http://www.wri.org/publication/natures-benefits-in-kenya

Map 2: National electricity grid of Kenya



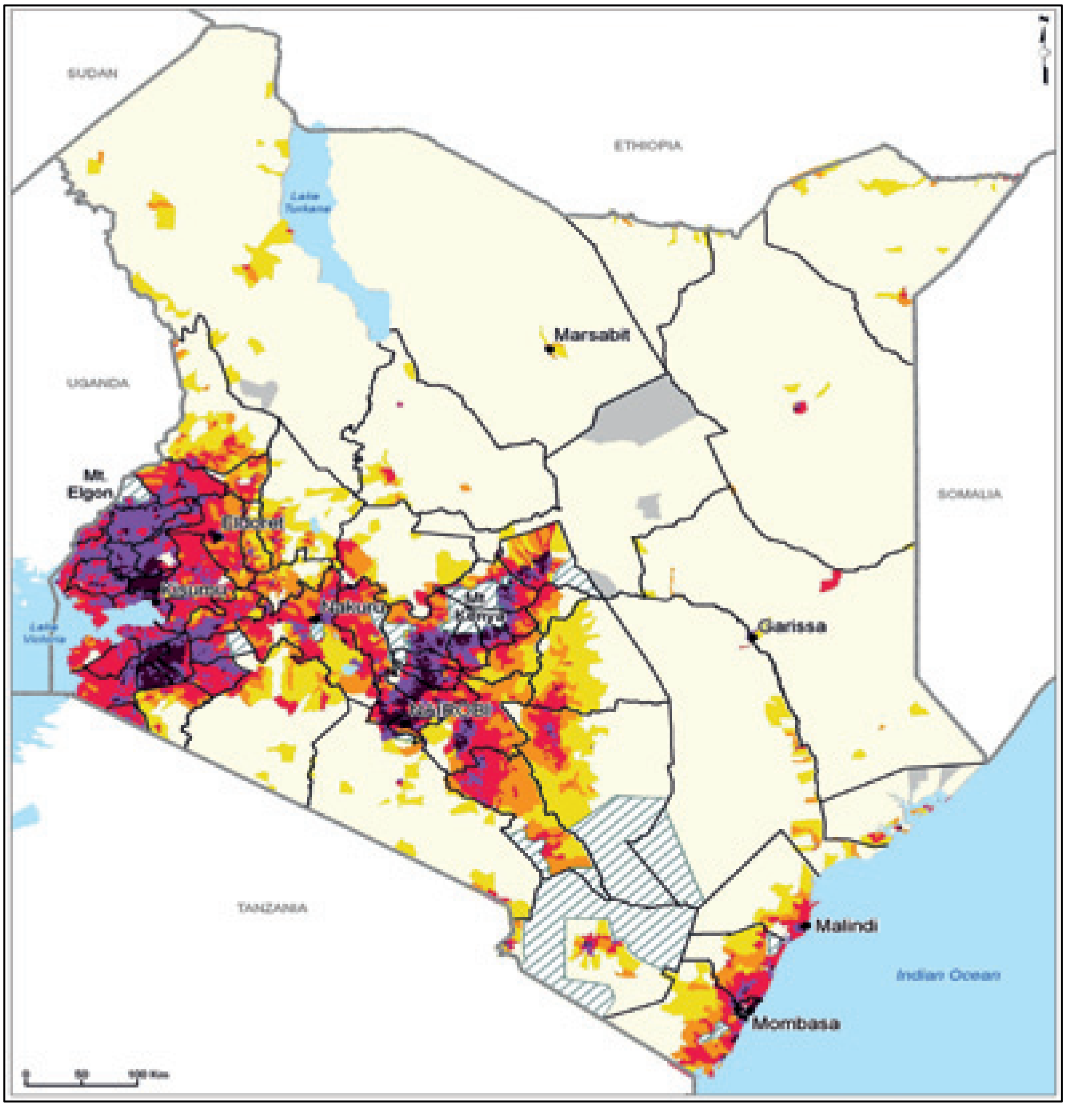
Map 3: Population density of Kenya (1999)

POPULATION DENSITY
(number of people per sq. km)

- > 600
- 300 - 600
- 100 - 300
- 50 - 100
- 20 - 50
- <= 20
- No data

OTHER FEATURES

- District boundaries
- Selected national parks and reserves
- Water bodies



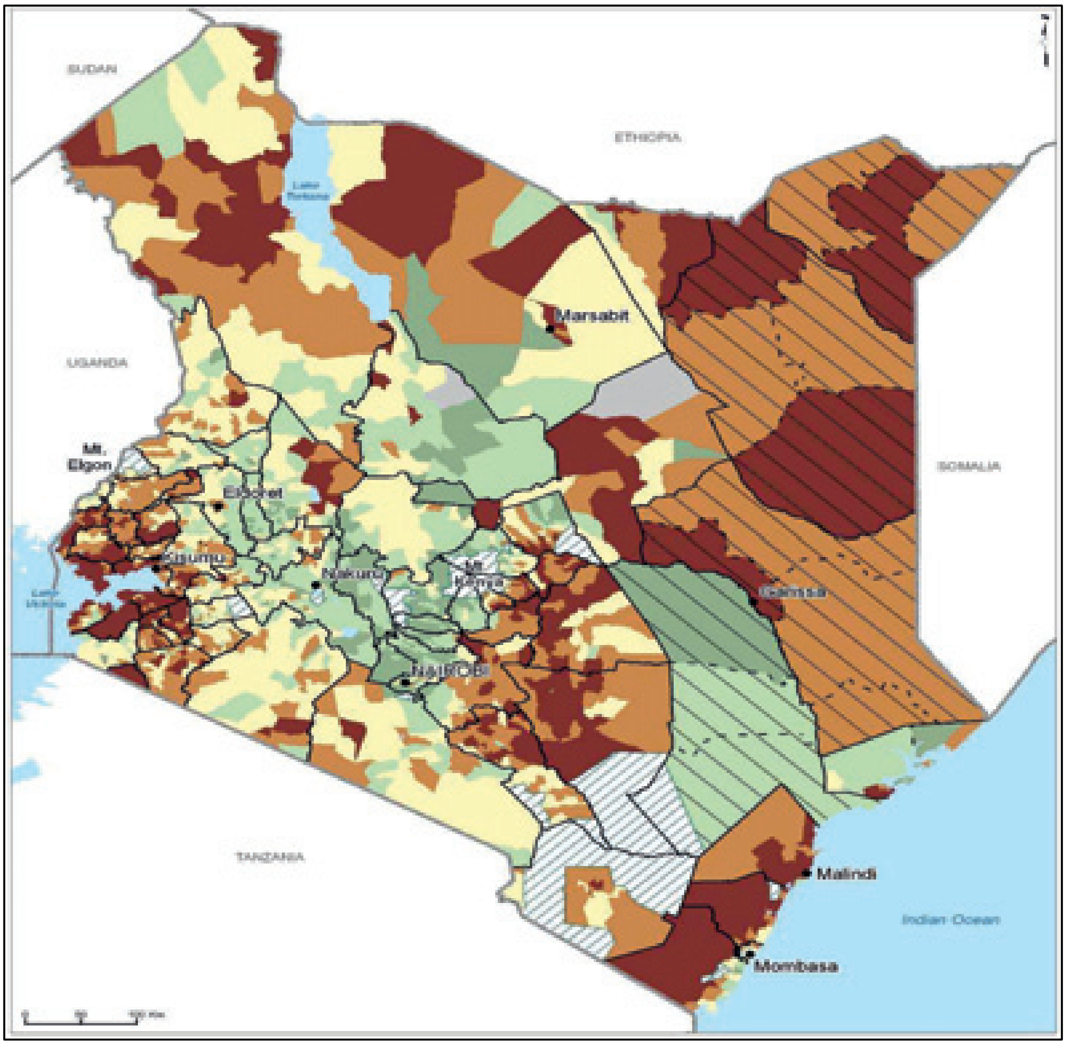
Map 4: Percent of the population below the poverty line

POVERTY RATE
(percent of the population below the poverty line)

- > 65
- 55 - 65
- 45 - 55
- 35 - 45
- <= 35
- No data
- Data calculated by Constituency

OTHER FEATURES

- District boundaries
- Constituency boundaries
- Selected national parks and reserves
- Water bodies



Map 5: Poverty density

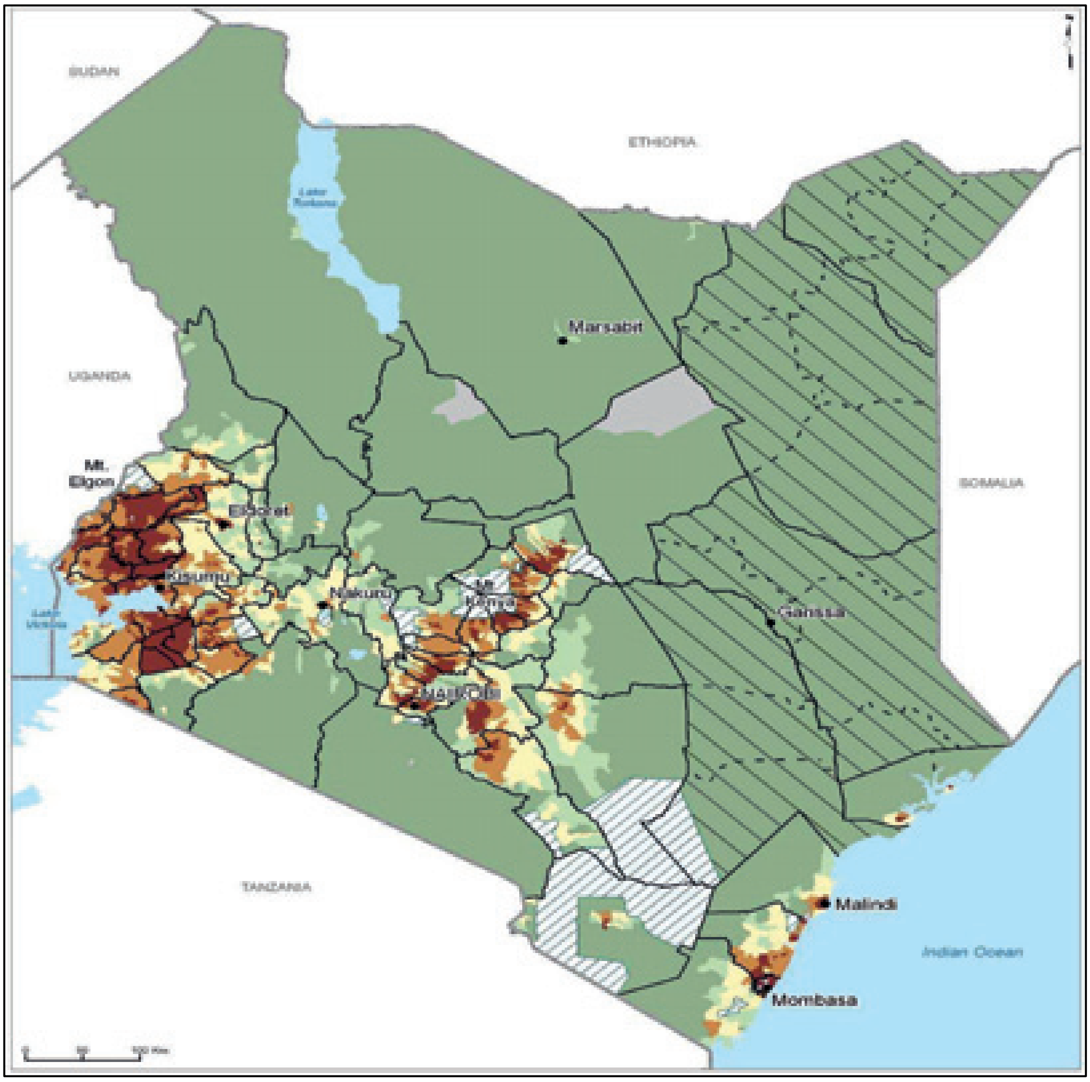
POVERTY DENSITY

(number of poor people per sq. km)

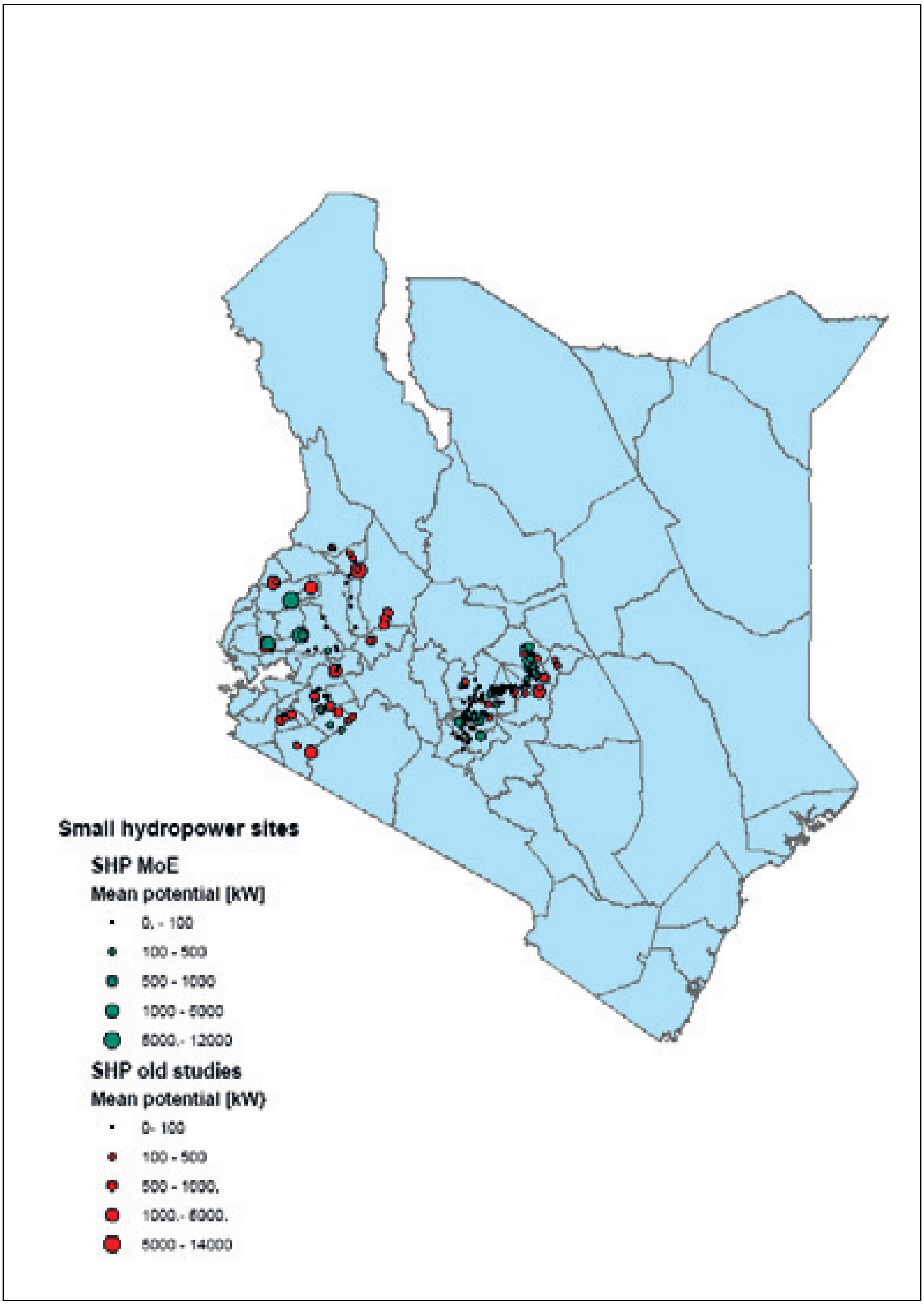
- > 200
- 100 - 200
- 50 - 100
- 25 - 50
- <= 25
- No data
- Data calculated by Constituency

OTHER FEATURES

- District boundaries
- Constituency boundaries
- Selected national parks and reserves
- Water bodies

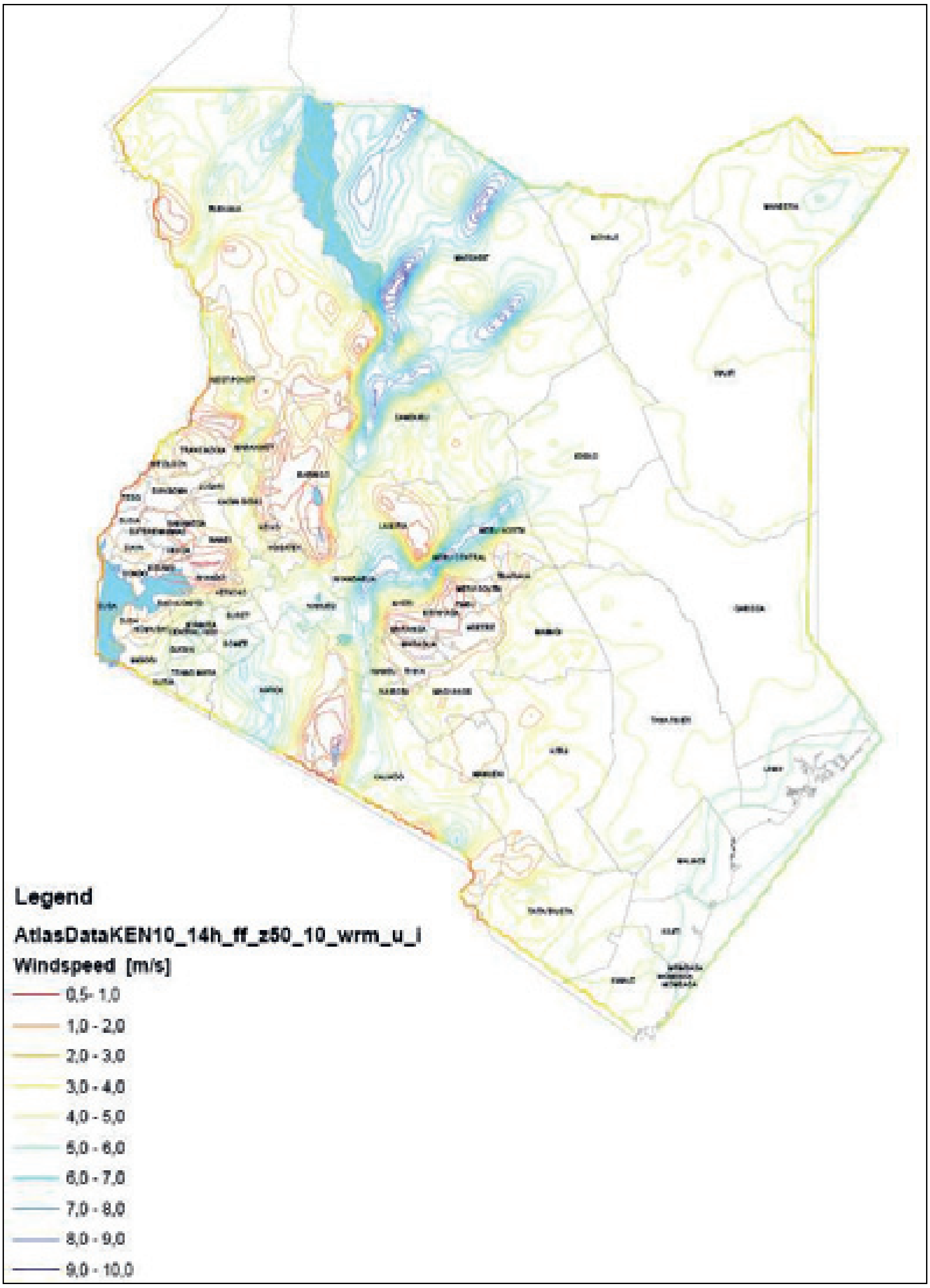


Map 6: SHP potential in Kenya



With regard to wind energy use, the potential in Kenya can be assessed in general as low to moderate, but specific areas have good to very good conditions. In general, the regions with the highest wind speeds are mainly in desert, mountainous and coastal areas.

Map 7: Wind energy in Kenya



In a stylized view, the overall potential for SHP development in Kenya under a poverty perspective could be described as follows:

The national grid has already reached (or will reach in the near future) the most densely populated parts of the country; The poverty density in these regions are high and at current tariffs and conditions, many poor people in these regions will not be able to afford connection to the grid; The majority of the potential SHP sites are located in the same densely populated regions. Therefore, SHP electricity in these regions will in many circumstances "compete" with the grid.

The situation in the least populated regions is different. Here, neither the grid nor SHP are strategic options. For economic reasons, the grid will not penetrate into these regions in the foreseeable future and SHP is of limited interest because most of these regions are rather flat and dry. By contrast, other renewable energy technologies, such as solar and wind, are probably of interest in these regions.

What does this mean for SHP promotion under a poverty perspective?

In Kenya, the national grid will continue penetrating into the regions with the highest potential for SHP development. SHP should, therefore, not only be seen as an off-grid technology but primarily as an option for increasing the share of hydro-electricity in the national grid. This development should be encouraged primarily under environmental aspects and with a view to creating jobs in the "SHP industry", which means construction and maintenance of SHP sites and in the medium term production of turbines and other SHP equipment.

Because most of the poor without access to electricity live in densely populated regions near to the grid. The poverty aspect would be best served by new approaches for providing access to grid electricity for the poor. Grid-powered "energy kiosks" could be a promising option for this.

Because, in the foreseeable future, the grid will not advance to the least populated regions renewable-energy powered "energy kiosks" seem to be a promising option for these regions. Because of the limited availability of hydro-power in these regions, most renewable-energy based energy kiosks would probably be solar or wind powered.

10.3 Small-scale Hydropower in Kenya

10.3.1 SHP potential in Kenya

Two major studies on potential SHP sites were carried out in 1979 and 1982. In the 1979 study, 11 out of 52 identified sites were recommended for more detailed research and 8 out of 39 identified sites in the 1982 studies. However, none of these sites has been developed to date.

As can be seen from Map 8.6, the potential SHP sites are mainly located in the south-west of Kenya (Lake Victoria drainage basin in Nyanza and Western Provinces and adjacent districts of Rift Valley Province) as well as in areas south-west of the line Mount Kenya – Aberdare Mountains (Central Province, Mt. Kenya adjoining districts of Eastern Province and Laikipia District of Rift Valley Province). Thus the SHP potential is concentrated in districts, which have also high population density and high energy demand.

In total, more than 260 small hydropower sites have been identified. Their estimated theoretical potential amounts to more than 600 MW. About 45% of the potential is located in the Lake Victoria Drainage basin, but the largest number of sites is found in the Tana River drainage basin, mainly in the districts of Kirinyaga, Thika, Maragua, Meru South and Meru Central. It is expected that systematic research could identify further low head sites.

To date, only the *theoretical* SHP potential has been explored. The potential that could be realistically exploited depends on technical factors as well as access and exploitation costs. Furthermore, the question whether a hydropower scheme operates off-grid or as a grid-connected system affects the design and the installed capacity. Conflict of use or water rights as well as environmental considerations and legal and concession aspects, such as the 3 MW thresholds between license and permit requirements, may reduce the actually exploitable power potential. Further investigations with regard to system sizing and costing will have to be carried out for those sites located close to the identified demand clusters for rural electrification.

10.3.2. SHP activities of other donors

SHP technology is not new to Kenya. There have been a number of SHP demonstration projects in the past prior to UNIDO's intervention. Furthermore, bi- and multilateral agencies such as GTZ and UNEP as well as NGOs are currently involved in SHP development. Activities with direct relevance for the UNIDO SHP projects should be briefly mentioned here.

A pioneering SHP project under the GEF Special Grants Programme has been implemented between 1998 and 2001 in Mbuiru (Meru South District) by ITDG Kenya in cooperation with UNDP.[37] This SHP has a capacity of 18kW and serves 400 households (3000 people). Reportedly, the project triggered at least two other SHP installations in its neighborhood.

Another SHP project has been of particular relevance because it is located in Kathamba (Kirinyage) very close to UNIDO's "energy kiosk" in Kibae and because it is a pico-hydropower installation of approximately the same power as the UNIDO turbines. This project was financed by the European Commission and installed by the Micro Hydro Centre at Nottingham Trent University as part of their programme to demonstrate Pico Hydro technology in Sub Saharan Africa.[38]

[37] Affecting Electricity Policy through a Community Micro-Hydro Project, Kenya; GEF/UNDP; 2001
[38] Community Pico Hydro in Sub-Saharan Africa/ Case Study Two/Thima, Kirinyaga District, Kenya; Nottingham Trent University; 2002

The installation is equipped with a pelton turbine of about 1.1 kW and the electricity is distributed to about 60 houses through wiring. Household loads are limited through current limiters and the system does not use electricity meters. Reportedly, the design flow of about 8 liters per second is available throughout most of the year. A small concrete weir was designed and the natural storage area behind the weir was enlarged by widening of the banks to 4 –5 meters width and 20m length. Reportedly, this set up provides sufficient storage to supply the extra flow required for 4 hours of evening lighting during the driest part of the year. The weir is equipped with a simple but efficient flushing gate for easy de-silting of the storage pond.

On a much larger scale, the European Union is financing seven mini-hydro plants in the Upper Tana region. The project is implemented by the parastatal Tana River Development Authority (TARDA). The estimated project cost is 1.3 million Euros for an estimated capacity of 3185 kW.

GTZ, KIRDI and the Nairobi based NGO Green Power are currently involved in a collaborative project "Mapping of Mini-Hydro Electricity Generation Potential in Western Kenya". The aim of this project is to mobilize funds for a massive SHP construction program in this part of the country. A detailed report with pre-feasibility studies covering 14 potential SHP sites in Western Kenya has been prepared in August 2008. The potentials of 12 identified sites are situated between 200 kW and 2 MW. Two sites in the range of 20 kW have also been included but the project considers that, in order to be economically viable, a minimum threshold of 200 kW should be applied.

10.4 UNIDO's SHP activities in Kenya

UNIDO's SHP related activities in Kenya have been executed under project XPKEN07001 "Implementation of 10 model pico hydro systems in Kenya". With the overall amount of 180,000 USD allotted to this amount UNIDO implemented pico-hydro turbines at four sites:

- Kibae, Kiangombe Division, Kirinyaga District, Central Region (150 km from Nairobi; two turbines installed at this site)
- Ikinu, Githunguri Division, Kiambu District, Central Region (29 km from Nairobi)
- Mathioya, Kagwanja Division, Muranga District, Central Region (75 km from Nairobi)
- Boito, Konoin Division, Kericho District, Western Region (300 km from Nairobi; two turbines installed at this site)

10.4.1 The planning of the UNIDO SHP project

The project document of project XPKEN07001 described the purpose of the SHP project as follows:

> *"This project is designed to establish 10 Pico Hydro energy systems for productive activities in the off-grid rural areas of the Mount Kenya region, with a view to jumpstart the energy component of the Kenya Integrated Programme based on a donation of 10 Pico Hydro units from the*

International Centre for Small Hydro Power, Hangzhou, China, as requested by the Government of Kenya. The project will be implemented in two phases: Phase I (3 months) will involve collection of technical data at sites selected from an array of sites provided by the Ministry of Energy and the design of civil works at selected sites for setting up the systems. Phase II (6 months) will consist of the installation of these systems at the selected sites."

The project document is not very clear with regard to positioning the project within a longer-term SHP dissemination strategy for Kenya.

While the document points out that "70% of Kenya will remain non-electrified for decades to come" it does not clearly explain that this not true for the targeted Mount Kenya region and other densely populated parts of Kenya where the grid is rapidly penetrating and that, in the target region, many poor people are excluded from electricity not primarily because of slow grid penetration but due to (for them) prohibitive connection costs.

Furthermore, the project document gives the impression that significant impact on productive use could be reached, while in reality the entire project has been built around the 1kW turbines donated by China. The project document mentions productive uses such as refrigeration, welding and the "establishment of more efficient agro-processing industries attracted by the availability of electricity in rural areas" but does not mention the limited power of the pico turbines. Instead, the document insists on several occasions on "jumpstarting" the SHP component of the UNIDO Integrated Programme in Kenya. The provision of computers for computer courses at village level, which subsequently has become a core feature for the "energy kiosks" approach, is not mentioned in the project document.

The project document envisaged a step-by-step approach including some important analytical work such as

- "a socio-economic study on how the access to energy, specifically electricity can have an impact on the empowerment of rural communities, particularly women and youth."
- "a project information report on 10 potential micro and pico hydro water resource sites in the Mount Kenya region, as prioritized by the Ministry of Energy of Kenya, which are economically viable for development with particular focus on productive activities for income generation and poverty alleviation."
- "review the overall map of the country and identify one priority region with adequate water resources for developing pico/micro hydro systems."
- "review time series data available for lean and peak seasons at each potential site."

The project document mentions "village communities enabled to use systems for productive use" as an expected project output but, except for technical training, the document does not elaborate on the activities that would be required to achieve this output. Alternative private user models are not mentioned, leaving the impression that the difficulties of setting up cooperative user models were underestimated when writing the project document. Given the experience with other community based SHP or electrification projects such as the "Multipurpose Platforms" the estimated duration of 6 months for construction and initiating productive electricity use was not realistic.

10.4.2. Kibae (Kirinyaga district)

The site of Kibae is the "showcase" of UNIDO's SHP activities in Kenya. It is located in the district of Kirinyaga, an area where considerable awareness and demand already exist for micro-hydro based village electrification schemes. Apparently, the widespread awareness of the population in the Kirinyaga district of the opportunities and benefits of this technology is a result of the micro-hydro village electrification scheme in the nearby village of Kathamba that was installed in 2001 (see above).

Based on the Kathamba example, the neighboring village of Kibae had already made an attempt some time ago to install a micro-turbine on the same waterfall that is now being used for Kibae. This earlier project has been abandoned for unknown reasons but the weir and the powerhouse that were constructed at the time on the other side of the river are still waiting to be equipped. This weir is located 50 meters upstream of the Kibae weir, thus both installations would be in potential conflict. In the meantime, the national grid has arrived at the district but it is not known how many of the estimated 1000 households of Kibae are already connected.

The weir installed by the UNIDO project has a major design problem because no flushing gate has been foreseen. This problem makes de-silting of the storage pond difficult and, according to the operators, has already caused service interruptions in the past. This basic design flaw is particularly surprising because the "model" installation in Kathamba has been equipped with a simple but efficient flushing gate.

The infrastructure for electricity use put in place by the UNIDO project in Kibae is built around a 2.5kW hybrid pico-hydro/solar PV unit and comprises the energy kiosk itself as well as a small industrial shed and a social hall for TV and video projections. The energy kiosk is managed by the committee of the Kibae Self Help Group. Reportedly, this group has 132 members.

The kiosk serves for LED lamp charging, mobile phone charging, car battery charging and as a computer training centre. Currently, the energy kiosk has sold or rented 52 lamps to the villagers of Kibae. To promote LED lamps among the population of Kibae, the kiosk offers different options such as hire purchase over a period of six months; monthly, weekly or daily rent; or simple charging services for those customers who already own a LED lamp.

Six students per month attend the computer training. The daily video and TV shows at the social hall reportedly gather around 10 people on workdays and 20 people during weekends.

In the industrial shed, UNIDO has installed a 1kW electric grinding mill, a poultry egg incubator, a soap mixer and a small juice-making machine. These technical appliances have been made available to the self-help group as a donation with a view to encouraging the development of commercially viable businesses. This expectation has, however, not yet materialized.

The monthly income generated by the energy kiosk of Kibae is estimated at about 27.000 Ksh with monthly expenses for salaries amounting to 7.500 Ksh. No data are available on other costs such as maintenance and repair. The total investment cost amounts to about 23,000 USD, including civil works and electrical equipment, except for the two pico-hydro-units themselves, which were donated.

The two 1kW pico-hydro units are complemented by a 2kW solar panel. This hybrid solution has become necessary because reliable flow data were not available and water resources are unpredictable during three months of the year. The Ministry of Energy asked UNIDO to equip the site with solar panels because it wanted to develop Kibae as a model hybrid /solar site. Obviously, the hybrid solution entailed additional technological complexity and a significant increase in investment cost.

An overall cost/benefit analysis including capital depreciation costs is not available. Therefore, it is hardly possible, at the present stage, to determine whether the community based energy kiosk model adopted in Kibae has the potential for replication at a regional or even national scale.

With a view to a possible up-scaling of the community based energy kiosk approach, the team of national UNIDO experts carried out a critical analysis of the Kibae experience. The following challenges were identified:

- Initially, the community members were disappointed that the project did not bring electricity into their houses. This disappointment is quite understandable given the experience of the villagers with the "model project" in Kathamba that had adopted some years ago the traditional house wiring approach

- The initial management committee was found not to have the necessary organizational skills. Therefore, the members of the self-help group elected a new committee hoping that the new committee situation can be changed

- Community response to the facilities being offered at the center has been slow due to limited awareness creation by the members operating the energy kiosk. The slow pick up of the energy services entailed economic problems for the running of the energy kiosk (not enough income), which if not remedied will affect its sustainability

- UNIDO has been under pressure to quickly spend the money from the 2006-2007 budget and to come up with immediate and visible successes. Too many innovative features were started at the same time, putting the members in a bit of dilemma, considering that the concept was entirely new. The spending and time pressure of the project has led to phenomena of "over-assistance" and negative consequences on ownership

The “productive use” aspect of the project encountered particular problems:

- The installed electrical capacity is not sufficient for the envisaged income creation activities because it will not be possible to run the different productive appliances in parallel. Moreover, the 1kW maize mill is too weak and technically not appropriate for producing flour

- Given the limited water flow during the dry season it will not be possible to rely on water energy alone for increasing the capacity of the installation. However, solar electricity will be far too expensive to run an electrical mill or an egg incubator on an economically viable basis

- Sustainability of the would-be businesses in the industrial center as well as of the energy kiosk itself is still not very clear. Committee members running the businesses have still not exercised the sense of ownership in terms of management of these businesses

- The community members who have been delegated to run the businesses lack entrepreneurial skills, marketing experience and technical knowledge and the management committee has not been able to contribute very much to the business management aspects. Overall, the self-help group lacks an agenda how to take the “productive use” aspect of the project forward

Despite these weaknesses, the energy kiosk of Kibae fulfills its demonstration purpose and attracts a considerable number of visitors.

10.4.3. Ikinu (Kiambu District)

Similar to Kibae, the energy kiosk in Ikinu has been set up by UNIDO at a site requested by the Government for which reliable flow data are not available. The kiosk in Ikinu has been implemented in collaboration with “Shelter 2000”. This Kenyan NGO supports the community of Ikinu since several years, for example with setting up small-scale irrigation schemes. The existing irrigation weir is being used at the same time as an intake for the pico-turbine. Shelter 2000 also constructed the powerhouse and the transmission line to the energy kiosk.

The energy kiosk is managed by the Kiababu Lighting Self Help Group. This group has more than 100 members but many of them do not contribute the agreed monthly fee of 10 Ksh (exact figures are not available). A manager employed by the group looks after the day to day activities of the kiosk, such as mobile phone re-charging, car battery re-charging, LED lamp re-charging and the computer training center. Three computer students are being trained per month at a lower price than the one at the private computer training centers nearby.

Reportedly, 110 rechargeable LED lamps have been sold or rented in Ikinu. This is a remarkable number compared to the energy kiosk of Kibae, which is powered by two turbines but has distributed only 52 lamps. Customers in Ikinu acquire the LED lamps through different options i.e. hire purchase at 250 Ksh per month for 6 months, monthly rental at 150Ksh, weekly rental at 50 Ksh and daily rental at 7 Ksh. This broad variety of options is considered useful and necessary for marketing purposes. The energy kiosk raises a monthly income of 17.700 Ksh, of which 8.500 Ksh are being used for salaries.

The Kiosk is currently located in a rented building but, with the help of Shelter 2000, the self-help group plans to construct a new building comprising the energy kiosk, a social hall and an industrial shed.

The very limited power generated by the pico-turbine will not be sufficient for any productive use beyond what has had already been set up. However, the recent arrival of the national grid in the village has profoundly changed the boundary conditions of the project anyway.

10.4.4. Mathioya (Kagwanya district)

The energy kiosk in Mathioya has been set up by UNIDO in cooperation with the local St. Paul's Anglican Church, where the centre is located. The area is served by the electricity grid but, reportedly, very few people seem to have access to the grid, because of connection cost. The site is reported to have a head of 12 meter and a flow rate of 8 l/sec. During the rainy season, the river is reported to have an electricity production potential of up to 10 kW.

The energy kiosk in Mathioya is technically finalized but not yet operational. The centre was ready for inauguration in April 2008, when unknown persons vandalized the transmission wires and poles. This kind of vandalism seems to be a frequent problem in rural Kenya, which is also being mentioned on the KPLC website. The rehabilitation of the installation is pending subject to security problems in the region.

10.4.5. Boito (Kericho district)

This site is located in Western Kenya, outside the initially agreed project area. There is no reliable hydrological data available but the theoretical potential of this site seems to be considerably higher than the capacity of the two pico-turbines, which serve two energy kiosks in two villages on both sides of the river.

The implementation of this project started in 2007 but has been affected by the post election violence. During several months UNIDO project staff was not allowed to carry out missions into this area. However, during this crisis, the communities' involvement continued with the construction of those parts of the installation, which were under their command. This commitment demonstrates a high degree of motivation and is a good sign for future sustainability.

The communities on both sides of the river constructed their respective energy kiosks without project support. The monthly income from recharging mobile phones, car batteries, torches and LED lamps reportedly amounts to 12.000 Ksh. To date, only 6 LED lamps and 10 torches have been distributed to Boito. None of the two centers is equipped with computers and thus no computer training takes place. To date, the sustainability of the two kiosks is not ensured. Reportedly, lack of expertise and knowledge on the side of the management committee led to poor marketing and relatively slow growth.

10.5. Rechargeable lamps

The innovative energy kiosk concept developed by the UNIDO SHP program in Kenya has the potential to increase the access of the poorest parts of the population to electric lighting. Rechargeable lamps (and other battery charging techniques) are at the heart of the energy kiosk concept. [39]

Over the last 10 to 15 years the technology of electric lighting has been affected by three major technological shifts: from incandescent to fluorescent to LED. Each of these shifts was characterized by a significant increase in efficiency. In Kenya and worldwide, a number of initiatives attempted harnessing the fluorescent and, more recently, the LED technology for rural lighting.

Between 1999 and 2003 the Kenyan NGO "Practical Action Consulting" developed together with a British firm and with funding from DFID the rechargeable "Glowstar" lamp.[40] This lamp was based on fluorescent lamp technology and received a UK trademark. Commercialization of the lamp seems to have ceased because since about the year 2000 white "Luminescent Electronic Diodes" (LED) have become available as a less expensive, more efficient, more reliable and less polluting alternative.

LED based rechargeable lamps are the technological basis of the joint World Bank and IFC initiative "Lighting Africa"[41]. Kenya is one of the five pilot countries of this initiative. Two detailed studies of the Kenya market have been carried out, which contain a wealth of information on the demand for and availability of LED based rechargeable lamps in Kenya. The studies cover different kinds of LED based lamps for households such as rechargeable lanterns, rechargeable task lights and rechargeable torches as well as rechargeable flood lights for traders. Prices acceptable to consumers for these devices were found to be 14 USD for lanterns; 10 USD for task lights and 3, 40 USD for torches.[42]

Independently from the Lighting Africa initiative, the UNIDO project in Kenya tested different types of rechargeable LED lamps that were available on the local market or imported by the project from India, China and Germany. An attempt was also made with assembling a rechargeable LED lamp from locally available components. Considerable differences were found with regard to price, reliability and acceptability of the different models. Although the project did not carry out a systematic analysis, these tests seem to confirm the urgent need for a quality assurance program to shield African consumers from poor-performing lighting products and avoid market spoilage.

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[39] With its "O-Hubs" the multinational OSRAM applies a similar concept under its Lake Victoria project (see Box 5.3).

[40] http://itcltd.com/glowstar/

[41] For more information on "Lighting Africa" see chapter 2 of this evaluation.

[42] The need for alternative lighting devices to be used by households connected to the grid should also be mentioned here. 54% of those households connected to electricity experience power cuts at least once a week. 57% of the power cuts occur between 19.00h and 7.00h. During these hours electricity is needed by 70% of households as these are the hours when the household is back home from their day time activities and require light to prepare dinner and for the children to be able to do their homework.

Such a product quality assurance program is under development as part of the "Lighting Africa" initiative to enhance consumer awareness, support industry in providing technologies tailored to African consumers, and boost confidence in new lighting products and services.
Under the "Lighting Africa" initiative a number of issues emerge that would fit with UNIDO's mandate. UNIDO could add considerable value by developing:

- A standard product testing method for the different types of rechargeable LED lamps
- Performance specifications to aid bulk procurements
- A code of principles for industry stakeholders
- A quality seal for off-grid lighting products

10.6. Assessment of UNIDO's SHP related activities in Kenya

The project document defined the "main objectives" of the project as follows:

- Prepare a project information report on the potential water resources in the Mount Kenya region, which are economically viable for development as well as economically beneficial for local communities with particular emphasis on establishing productive applications for income generation and poverty alleviation
- Implement ten pico-hydro machines in connection with productive use
- Train local experts and technicians to set up and maintain pico- and micro-hydro units

On the same page of the project document the first two of the three "main objectives" are repeated but this time as "outputs" while the third "main objective" related to capacity building is repeated as an "activity". The project document does not mention outcomes, assumptions or indicators. No logical framework is provided.

As a result of these logical flaws in the project document a methodologically sound evaluation of UNIDO's SHP related activities cannot be carried out on the basis of this document.

In order to enable an assessment of the project, a number of common sense assumptions had to be made about the potentially underlying intervention theory of the project. Due to the absence of a logical chain, the standard evaluation criteria of "relevance", "effectiveness" and "efficiency" cannot be applied as usual. Thus, there may be some room for interpretation with regard to the structure (not the substance) of the following analysis.

10.6.1 Relevance

The underlying (although not explicit) objectives of the project seem to be providing electricity access to the poorer parts of the population and promoting the productive use of electricity from renewable energy sources. These objectives are highly relevant but the approach of the project was poorly calibrated towards reaching these objectives.

The capacity of the donated pico-turbines is insufficient for significant productive uses. Moreover, developing and equipping the sites with turbines of such limited capacity could be considered counterproductive in at least two respects. First the sites are underequipped and, thus, the available renewable energy resources are underexploited. Second, a negative and misleading demonstration effect may occur in so far as SHP could be perceived as "too weak for serious productive use".

Quite clearly, the project has been largely built around the donated pico turbines, hence driven by technology supply.

Furthermore, the objective of providing electricity access to the poorer parts of the population could be reached more effectively and on a wider scale by combining the use of rechargeable lamps not with pico turbines but with grid connection. It should be reminded here that, at the moment of the evaluation, the central grid had already arrived in proximity of the project sites.

10.6.2. Effectiveness

The objective of preparing *"a project information report on the potential water resources in the Mount Kenya region, which are economically viable for development as well as economically beneficial for local communities"* has not been reached. No such report is available. The identification and selection of the four sites was based on Government requests, including the site of Boito in Western Kenya, which is located outside the initially targeted Mount Kenya region. There is no evidence of a systematic review and priority setting process as envisaged in the project document. Time series of hydrological data for lean and peak seasons have not been made available. The "project information report on 10 potential sites" and the "socio-economic study" mentioned in the project document have not been prepared.

The objective of developing 10 sites with pico turbines is partially reached. Four sites were equipped, two of which with two turbines each. The four sites show the following commonalities:

- Battery charging facilities located in a collectively owned community centre for which the project coined the name of "energy kiosk"
- Electricity distribution not through household wiring but through rechargeable LED lamps and battery charging
- Community based cooperative user model with monthly member fees and without for-profit private sector involvement

In the energy kiosks of Kibae and Ikinu the project installed computers for village computer courses. Equipping the energy kiosks with computers was not foreseen in the project document. This decision enabled at least some kind of "productive use" in addition to lighting but at the price of distorting the cost structure of the demonstration sites. Running computers with pico turbines requires the use of additional sophisticated equipment (inverters). This equipment is more expensive than the turbine itself and therefore distorts the cost structure of the demonstration sites. Using solar powered low-voltage computers instead of stabilizing the entire 1kW electricity production of the turbine by means of an inverter would probably be more appropriate.

Moreover, the computer training centers set up by the project with donated computers seem to compete with similar private training centers that exist at a distance of a few kilometers from both “energy kiosks”. The rationale of competing with private computer training providers is not clear.

The “productive use” issue has been tackled at the site in Kibae, where the project installed a shed with mechanical appliances for productive use. However, the approach for developing productive use is exclusively based on the installation of donated electrical equipment. Some of this equipment is technically not appropriate and no viable business model has emerged yet.

10.6.3. Efficiency

The four installations were implemented between September 2007 and May 2008. Project efficiency was heavily affected by the post-election riots and tensions during this period.

The project contracted several international consultants from India, Sri Lanka and Germany for the design of the civil works, the installation of the turbines and other related expertise. However, some of these experts could not work as planned due to security problems. No reports from these experts are available.

The International SHP centre in China, which donated the turbines, did not participate in the design and installation process. The competent services of the Government of Kenya were consulted but not actively involved in the implementation of the project.

In order to assure the continuous support and supervision of the four sites UNIDO contracted a team of four young Kenyan professionals. This team brings in a good mix of technical and socio-economic experience, which is commensurate to the complexity to the task. For each of the sites the team prepared a short status report including an assessment of the challenges and recommendations on the way forward.

10.6.4. Sustainability

The demonstration approach of the project relies entirely on donating equipment to village communities and on a community based business model. No attempt has been made to come up with cost-benefit analysis and scenarios taking into account depreciation and capital cost. Therefore, the economic viability of the current community based “energy kiosk” model remains to be demonstrated.

Private sector based business models that might be commercially more viable have not been developed or tested. Battery charging is a thriving commercial business throughout rural Africa that could be considerably boosted by the promotion of rechargeable LED lamps.

Such a market based approach is the underlying philosophy of the "Lighting Africa" initiative of the World Bank. Kenya is one of the four pilot countries of this initiative and it is hard to understand why the project did not embark on a more market based approach instead of limiting its activities to a community based approach with uncertain sustainability perspectives. A diversified approach experimenting different user models would have been more adequate for a "pilot project".

11

UNIDO SHP project in Indonesia

The UNIDO Country Service Framework in Indonesia included the establishment of a Small Hydro Power Plant and a Community Development Center on the island of Nias, which was heavily affected by the tsunami in December 2004 and an earth quake in March 2005.

The SHP project in Nias was evaluated by an independent expert in May 2008. The following text is extracted from the evaluation report of the CSF Indonesia.

11.1. Project background

This project had two objectives:

i) To supply the rural community in Nias with environmentally sound, affordable and adequate electricity (which will expectedly increase employment opportunities, improve the ecological environment, reduce poverty, improve livelihoods, and stimulate economic development activities in the targeted areas)

ii) To establish a Community Development Center (CDC) (with a view to facilitating specifically growth of micro-industry, sustainable agriculture, health care, education, information and communication facilities and the use of electricity to bring efficiency into all possible aspects of rural like and serve a demo project for duplication in similar conditions in other areas)

Table 11.1: Project data on Indonesia

Project name	Alleviation and Restoring Sustainable Livelihoods in Nias Island Through Micro Hydro Power Based CDC for Common Facilities
Project number	FBINS05006, XPINS05005, XPINS07002
Total planned cost ($)	311,000
Total allotment ($)	338,820
Expenditure rate (%)	91
Donor	OCHA, UNIDO
Start date (first PAD)	September 2005
Actual completion date	May 2007
Planed implementation period	1 year
Status	Closed, but bridging project is expected soon to complete all activities

Source: UNIDO InfoBase and project documents as of May 2008

11.2. Project assessment

11.2.1. Relevance

The provision of electricity from a small hydro power plant (SHP) remains a highly relevant intervention in Nias in particular and in Indonesia in general, as SHPs are mostly suitable for mountainous areas with reasonable levels of rainfall. After a powerful 8.7-magnitude earthquake hit Nias in March 2005, the local government and the Agency for Rehabilitation and Reconstruction for Aceh and Nias (BRR) recognized the need to improve access to electricity. As a result, the BRR contributed nearly $120,000 to the project right from the beginning of the reconstruction phase in order to rebuild the island's infrastructures.

The project objective had clearly shifted between May 2005, when the project concept was developed in the CSF II document, and September 2005, when the specific project document was prepared. The objective had changed from *developing SHP to provide energy for productive uses* to what turned out to be *installing environmentally sound, affordable and adequate electricity generating facility with* [emphasis added] *a Community Development Centre (CDC) attached to it*. Thus the project emphasis shifted from supplying energy specifically for productive uses (which is in line with UNIDO's mandate and core competencies) to generating electricity for a CDC and other unspecified uses.

An Information and Communications Technology (ICT) Community Development Centre (CDC) in remote areas can be, in principle, a highly relevant development tool. However, such CDC and ICT provision needs to be firmly based on thorough needs assessments and a solid business model with financial viability, proper plans of managerial oversight and clear post-project ownership. There is no evidence that such needs assessments were undertaken in designing the project or during the early project implementation. The project document does not present any clear justification for ICT community development centers but has clearly unrealistic assumptions of their effects: '*The project has also an object of establishing a Community Development Centre, with a view to facilitating specifically growth of micro-industry, sustainable agriculture, health care, education, information communication facilities and the use of electricity to bring efficiency into all possible aspects of rural life and serve as a demo project for duplication in similar conditions in other areas'*.

In practice, the project established two ICT centers. The relevance of these ICT CDCs is questionable given the unknown demand for their services, the unidentified target groups, and the difficulty and high costs in connecting to the internet and paying for such connection on an ongoing post-project basis. The relevance is even weaker as there is no connection between the SHP and the CDCs, which obtained electricity from somewhere else.

The relevance of the Nias SHP and CDC project is mixed. On the one hand, electricity provision through a small hydro power plant is highly relevant to the needs of the local community, is well supported by the local authorities and clearly falls into the competence of UNIDO. On the other hand, it is not clear what an ICT community development centre can contribute to rebuild the livelihoods and infrastructure of affected communities immediately following natural disasters.

11.2.2. Effectiveness and results

At a simplistic level, the project has achieved the two main expected outputs at its completion: i) a technically sound small hydro power plant and it associated distribution system; and ii) two CDCs equipped with computers and a satellite to connect to the internet[43]. The project has built a suitable hydro power plant that physically should be able to operate smoothly and meet its rated power output, at least in the wet season[44]. There are some small breakdowns but they can be easily fixed, such as the leaks in headrace. The local government and the BRR seem to be broadly happy with the plant, and to be prepared to support the necessary remedial actions and any project replication effort by UNIDO and other agencies.

However, the project has not reached its longer term results in supplying the targeted community in Nias with electricity, not to mention facilitating the growth of micro-industries, sustainable agriculture, health care, education and so on. Although the SHP and its distribution system had been constructed and had been able to function at the time the evaluation team visited the project in May 2008, the SHP was not operational. Each of the 200-targeted households had installed their own load management systems, which altogether exceeded the maximum load capacity of the 40kW power plant. This automatically shut down the SHP each time it was turned on. As the recipient households could not agree on a suitable load control mechanism, the SHP remained shut down.

The evaluation team found evidence that the households had not been adequately involved and consulted in the plant construction, although initially they were invited to several meetings organized by the project management. As a result, they did not have a sense of ownership towards the plant. An existing local committee, which was supposed to operate the plant, was not trusted by the community and could not mediate a solution. Many critical questions regarding electricity distribution among the community remain unanswered: How much electricity should each household among the targeted 200 obtain from the limited electrical output of the 40kW SHP? For which purpose should the electricity be used, for social or productive uses? Who is going to run and maintain the SHP? How will the resources be obtained to pay to run and maintain the SHP and its distribution system? How much should the households pay for their electricity, and what credit control protocols are to be followed in the event of non-payment? What is the maximum load each household should have, and how will this be enforced?

There is now a reasonable quality power plant and distribution system, but it is not able to operate, as the necessary community ownership and leadership are

[43] The evaluation mission could only review reports and talked to some of the project stakeholders and managers, but could not visit the two CDCs due to time limitation and dispersion of project sites.
[44] The feasibility study of the SHP site took place in the dry season. It is therefore not clear whether there will be enough water in the dry season to run the SHP.

not yet in place to facilitate the recipient households to agree on and implement critical actions.

Similarly, after some computer training, the two CDCs and their ICT equipment were no longer used. The effects of the CDCs on the users and the training participants remain unknown as the project did not collect and report on results information.

In addition, there was no real synergy between the SHP and the CDCs. Both CDCs were built before the SHP, so the CDCs obtained their electricity from other sources. One of the centers was located at the other end of Nias Island, far away from the community benefiting from the SHP, and had absolutely no link to the SHP or the other CDC.

The overall project effectiveness is moderate. But if the community is mobilized and strengthened and could take over the SHP from the project and run the plant smoothly on its own, the project effectiveness would increase. Additional funding is being sought to address these issues.

11.2.3. Efficiency and project management

The project was planned to last for 12 months but nearly three years after the start-up, it has not yet been fully completed. The budget was planned at $311,000, but by the time of the evaluation, the estimated costs were about $540,000[45], an increase of more than 70% of the original budget. The only additional output was one extra CDC, thus the project built two centers instead of one as planned. During the early implementation period, the project diverted most of the available funds into building two community development centers, buying computers and two satellites and connecting the CDCs to the internet. As a result, insufficient funds were left to construct the SHP, even though it was the primary objective of the project. To make up for this, additional funds were then mobilized from UNIDO and the local government. This process caused delays and consumed time and effort of the concerned managers and staff at the UNIDO HQ to prepare and review proposals for extra funding and to handle administrative procedures. So far, at least three bridging projects (Project Allotment Documents) have been opened in the UNIDO financial system just for the Nias SHP and CDC project to complete its activities.

The transaction costs were high for UNIDO to implement such a relatively small project in a remote area in Indonesia from the UNIDO HQ in Vienna. Numerous administrative papers were required to transfer funds from Vienna to UNIDO Jakarta office and then to the project office and service-providers in North Sumatra Province.

The project management went off track between 2005-2007 by over-emphasizing the CDCs and ICT equipment element. Generally, monitoring was weak and useful mandatory reports were not prepared. The proposed Advisory Committee with representation from the local Government, that was supposed to coordinate

[45] This includes both the government contribution in cash and the additional forthcoming funding from the BRR and UNIDO.

and support the project implementation, was never established. Since 2007, the new project management has rightly refocused on the SHP element and has recognized the importance of community mobilization. Although community participation is a particular challenge at this late stage of project implementation, it is the necessary prerequisite for post project sustainability.

In summary, the overall project efficiency has been modest as there have been many delays and the benefits from the main outputs have been low, although the budget has been overrun by 70%. However, once the SHP is made functional and starts providing electricity to the targeted households, the efficiency can then increase to a moderate level.

11.2.4. Sustainability

The Nias SHP and CDC project has achieved modest results and its post-project sustainability is still very uncertain. At the time of the evaluation mission, the small hydro power plant was not operating, the distribution system was not being properly repaired when the wires had come loose from power poles, and leaks in the headrace were not fixed. More importantly, no local entity with the necessary trust from the community was ready to take over the plant from the project and run it in a sustainable fashion. The project document foresaw the need to involve the local community in operating and maintaining the SHP, but did not plan or allocate suitable budgets for the necessary community mobilization and development. As a result, the community sense of ownership to the SHP was nearly non-existent.

The ICT equipment in the CDCs was no longer being used, and there seems no realistic prospect that they will be used again in the future in a sustainable way. The connection fee to the internet via VSAT (Very Small Aperture Terminal Satellite Systems) was expensive and it should have been obvious that the local communities would struggle to keep paying this high fee post-project.

The Nias SHP should still be able to be made sustainable, if the project starts mobilizing and mediating the community intensively for six to 12 months to increase the community ownership and leadership. Funds to cover this corrective intervention are being mobilized from UNIDO and the BRR. The extra funds seem likely to be forthcoming. The BRR remains willing in principle to provide funds to replicate the model in other parts of Nias and Aceh, if the SHP model proves successful. The project impact would be substantial if the pilot SHP was to be replicated into a series of stand-alone and grid connected small hydro power plants in Nias and Aceh, with funding from the BRR.

11.3. Recommendations

- The forthcoming funds should focus on strengthening and mobilizing the targeted community to take over and operate the SHP. Critical issues regarding electricity distribution and the SHP operations and management must also be discussed and resolved among the households

- Future SHP projects should ensure that at the project start-up the local recipient community will: (1) assist in the physical SHP construction (e.g., providing local materials or labour), if suitable, and learn how to maintain the plants in the long run; (2) agree on how the electricity will be shared and used for productive versus social activities; (3) establish suitable rules for credit control, disconnection for non-payment of tariff and maximum allowable loads; and (4) set up a suitable entity (e.g., local cooperative or trust) to control and manage funds for SHP operations and maintenance

- Future SHP projects should strengthen the strong and explicit link between electricity provisions and productive uses

- For a SHP, it is important to obtain accurate estimates or baseline hydrology data for at least a year on the major local climatic extremes (e.g., wet and dry seasons) so that the SHP can realistically achieve its design output across the year or by season

- If the SHP is intended as a pilot or demonstration plant, it is necessary to put in place a mechanism to capture, learn from and promote innovative elements right from the project design and during project implementation. Replication hardly takes place by itself

12

UNIDO SHP project in Mali

Under the energy component of the Integrated Programme in Mali UNIDO installed a Small Hydro Power plant of 3 kW near the small village of Sirakorobougou. This activity has been assessed in September 2007 by an EVA staff member as part the independent review of the IP Mali.

The review report of the IP Mali is in French with the exception of the executive summary, which is in English. The following text is extracted from this review report. More recent information is not available, as no progress or self-evaluation reports have been prepared.

12.1. Summary assessment

The micro hydro-power station (MHPS) installed by the Integrated Programme is the first installation of this kind in Mali. This is a considerable success. However, the electrical power produced is too limited for productive use. The MHPS has not yet been tested and is not yet functional. Overall there is still a considerable risk that this success might turn into a failure, if not followed-up properly.

The planning and design of the MHPS has been pretty much ad-hoc and its electrical power is much lower than expected (3 kW). National experts expressed the opinion that the hydraulic power available at the site is much higher than the power actually exploited by the installation. It is unclear whether the experts from the *« UNIDO International Centre for Small-scale Hydropower in Hangzhou, China »* who identified the site might have under-dimensioned the MHPS. The report they delivered is basically a one-page sketch of the on-site conditions. It does not contain detailed calculations or any considerations of the intended use of the electrical energy.

The civil engineering part of the installation has been designed and supervised by a UNIDO consultant and financed by the Government. Due to local conditions poor quality sand and gravel had to be used. Due to heavy rainfalls the civil engineering parts have been damaged and repaired already twice. The installation is at risk and needs to be constantly supervised, secured and maintained. At the moment the sharing of responsibilities between UNIDO and the Government is not yet clearly agreed.

At the moment there are no concrete plans for a “productive use” of the electrical power generated. The Government plans to integrate the installation into a future electrification scheme that is planned in a nearby village. In case this electrification project would be delayed there is a risk that the installation remains unused and thus of an “adverse demonstration effect”.

Another more powerful hydro-power site exists not far away from the present site with a nearby tea factory that is suffering from power shortages. This site would be ideal for up scaling the experience and demonstrating “productive use”. The government is planning to develop this site. UNIDO should join forces and offer its technical assistance and both sides should engage in joint funds mobilization.

12.2. Detailed assessment (in French)

Le document du PIM prévoit *« dans une phase préliminaire la mise en place d'une petite centrale hydraulique. Cette unité devra fournir du courant électrique aux villages environnants et pourra appuyer le développement d'activités de valorisation des produits agropastoraux. Une fois sa viabilité technique et économique prouvée, il est prévu d'installer d'autres unités sous réserve de la disponibilité des financements nécessaires. »*

Le document du PIM ne précise ni le site, ni la puissance de cette centrale. Ceci met en cause le caractère sérieux de l'estimation du budget de ce volet (405.000 USD) avancé dans le même document.

Face aux difficultés des deux partenaires de mobiliser le financement prévu et suite à la décision de l'ONUDI de mettre à disposition un fonds d'amorçage, le responsable de projet au siège de l'ONUDI demandait en 2005 au « UNIDO International Centre for Small-scale Hydropower in Hangzhou, China » d'envoyer une mission de reconnaissance au Mali. Dans la même année, les experts chinois visitent, ensemble avec un représentant de la Direction Nationale de l'Hydraulique, en certain nombre de sites dans la région de Sikasso mais aucun rapport de mission ne parvient au Gouvernement ni au chef des opérations de l'ONUDI au Mali.

Peu après cette mission de reconnaissance, le responsable de projet au Siège est muté comme représentant de l'ONUDI au Kenya et ce n'est que suite à une initiative du chef des opérations de l'ONUDI au Mali que le Centre Hydro en Chine soumet un rapport. Ce rapport identifie le site de Sirakorobougou et décrit très sommairement les caractéristiques et les potentialités hydrauliques de ce site sans pour autant préciser la puissance électrique visée par la réalisation. La contrepartie malienne est surprise de ce choix puisque ce site n'est équipé d'échelles limnimétriques que depuis 2005 ce qui limite la disponibilité de données hydrauliques fiables. Les estimations du potentiel par le service compétent se situant entre 10 kW et 35 kW, le gouvernement décide néanmoins de mobiliser plusieurs millions de FCFA du budget national pour couvrir les travaux de génie civil.

En septembre 2006 une turbine et un générateur en provenance de Chine arrivent sur le terrain ainsi qu'un expert indien contracté par l'ONUDI. En examinant la nature de l'équipement envoyé l'expert et son homologue malien découvrent la puissance très limité de cet équipement de 3 kW. Malgré cette surprise les autorités décident de procéder à la réalisation des travaux de génie civil. Ces travaux sont supervisés en partie par l'expert indien, qui dans son rapport mentionne des problèmes quant à la qualité des matériaux de

constructiuon, qu'il juge insuffisante : *« Quality of sand and gravel being collected for concrete work is really very poor… The quality of work will be very poor. »*
Les travaux de construction et d'installation de la turbine sont terminés en mai 2007. Faute d'une étude de faisabilité c'est à ce moment que la question de l'utilisation de l'énergie hydroélectrique semble se poser pour la première fois. Il s'avère que l'électrification de l'agglomération visée nécessiterait une puissance d'environ 20 kW et que cette agglomération se trouve à une distance d'environ trois kilomètres. L'alternative de limiter l'exercice à la seule électrification d'un petit hameau avoisinant la turbine pourrait constituer une solution mais est jugé impraticable par les autorités locales pour des raisons politiques et sociales.

Entre-temps la saison des pluies commence. Pendant le mois d'août 2007 l'ouvrage hydraulique est endommagé deux fois par de fortes crues. Une partie du canal d'emmenée est emportée par les eaux de débordement du barrage, mais reconstruit et partiellement renforcée aussitôt. Une deuxième crue encore plus forte inonde le bassin et emporte les remblais qui couvrent la conduite forcée. Cet état des lieux se présente au ministre de l'énergie à la fin du mois d'août lors d'un passage pour visionner le progrès des travaux.

Il ne peut pas être surprenant qu'un certain degré d'amertume et découragement se font sentir au moment de la mission d'évaluation. Néanmoins, les autorités décident de ne pas abandonner le projet mais de lancer l'électrification conventionnelle du village avoisinant tout en prévoyant l'utilisation de la micro-centrale comme une source d'énergie d'appoint.

Conclusions

- La centrale de Sirakorobougou est la première micro-centrale hydraulique au Mali. Depuis plus de 20 ans le potentiel important de cette source d'énergie au Mali a été discuté dans de nombreuses études sans qu'une réalisation, même modeste, s'en suive. La centrale de Sirakorobougou a le mérite d'exister mais l'ONUDI a adopté une approche de réalisation ad-hoc, peu orthodoxe et risquée.
- Dans le document initial de programme la base de planification de la micro-centrale est extrêmement faible. Ni le site, ni la puissance, ni la source de financement n'ont été identifiés.
- Le site à été identifié par une mission d'experts du « UNIDO International Centre for Small-scale Hydropower » en Chine. Cette mission n'a soumis aucun rapport qui aurait pu servir comme base de décision au gouvernement malien. Notamment, la mission n'a développé aucune stratégie en ce qui concerne l'utilisation de l'énergie.
- La puissance très limitée de la centrale de 3 kW permet l'électrification de quelques maisons mais une éventuelle utilisation de l'énergie à des fins productives serait très limitée.
- Les travaux de génie civil se sont déroulés sans aucun plan de construction préalablement établi. La résistance des ouvrages est incertaine due aux limites du financement disponible et à la pauvre qualité des matériaux de construction.

- Il est à espérer que la contrepartie malienne poursuivra son projet d'électrification conventionnelle du village avoisinant. Dans le cas contraire l'ONUDI court un risque élevé que l'effet de démonstration sera négatif.

Mutobo (Rwanda): Powerhouse

Gatubwe (Rwanda): Weir

Nyamyotsi I (Rwanda): Productive use (battery charger)

Nyamyotsi I (Rwanda): Productive use (locally produced welding transformer)

Kinko (Tanzania): Heavy silt load but no proper curing facility

Kinko (Tanzania): Canal exposed to erosion and not covered

Kinko (Tanzania): Manual sugar cane crushing could have been be an opportunity for "productive use" but was not considered

Kenya: Rechargeable lamps of various types, some of them locally produced

Kenya: The central grid has reached the vicinity of the energy kiosks

Kirinyaga (Kenya): UNIDO energy kiosk

Kirinyaga (Kenya): Battery charging

Kirinyaga (Kenya): Two chinese pico-turbines in parallel

Kirinyaga (Kenya): Ballast loads

Sirakorobougou (Mali): Dam

Sirakorobougou (Mali): Canal

Sirakorobougou (Mali): Chinese turbine (3 kW)

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