Consolidation of Pico Component of MHPP

2007 - 2008

Tim Chiaradia

Principle of a small hydropower installation

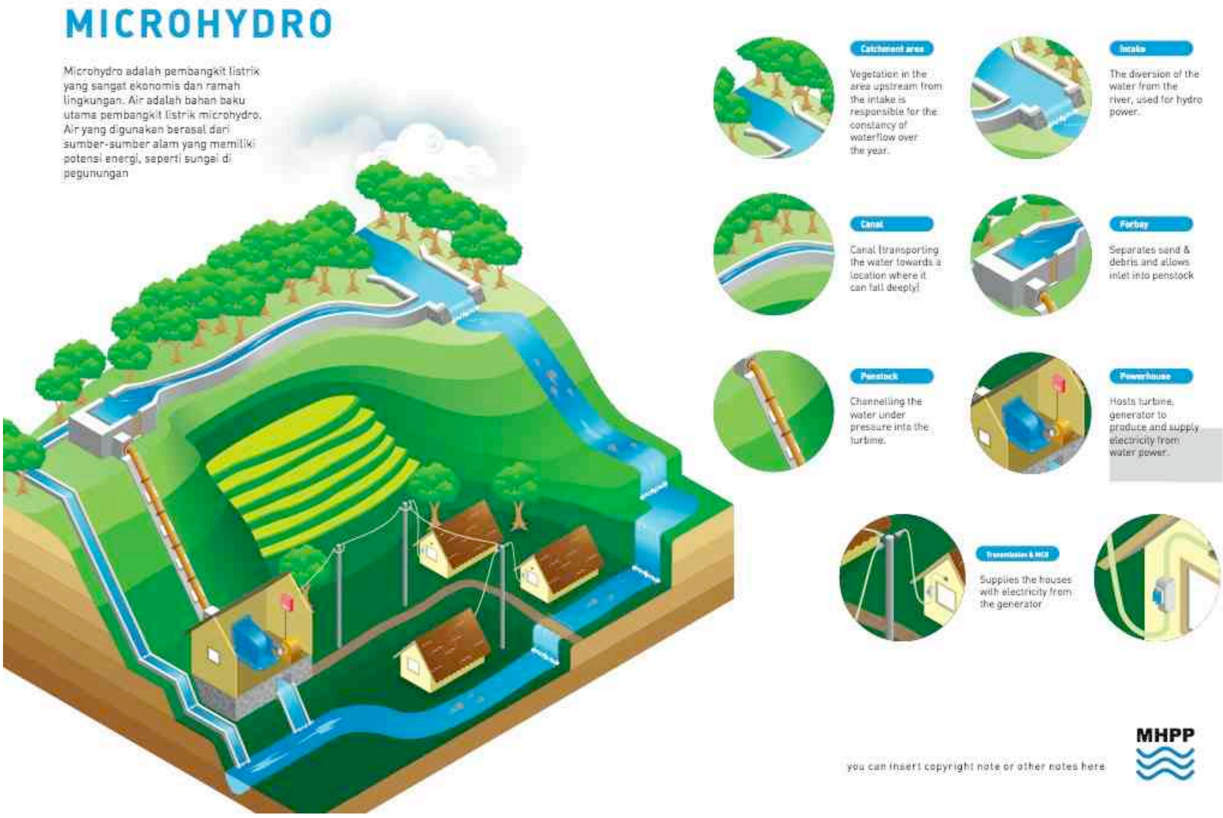
Hydropower is one of the most feasible solutions for electrification in rural Indonesia. Here can pico turbines help to spread benefits of hydropower all over the islands.

1 MHPP's Family Hydro component

1.1 Introduction

A large share of Indonesia's rural inhabitants has no access to modern forms of electricity. Indonesia, however, is fortunate in possessing abundant renewable energy resources. By far the largest and most accessible of these are the water resources in rural areas. Many of which can be harnessed for developing small-scale micro hydropower (MHP) projects suitable for rural electrification projects.
One challenge of utilising the micro hydro potential is the implementation of schemes in the far remote areas. Those areas with dispersed settlements are difficult to reach as they are often in mountainous regions with limited road access.
Family Hydro (FH), are small Pico hydropower schemes with a capacity of less than 5 kW. They provide technical solutions for individual household electrification. It's technology for rural electrification programs, for energy services via local distributors or "just" as exemplary introduction of mini hydropower into new focus areas. The economic viability of FH is given even if compared to diesel gensets. High upfront investment costs handicap the dispersion of MHP in rural areas, since the targeted customers mostly have no capital to invest. Financing mechanisms are hard to be accessed.
To establish FH as a business, one has to deal with the complications mentioned above: difficult access, dispersed clients and low capacity of cash money. On the other hand Family Hydro satisfies the most basic demand, electricity, for a very compatible price utilising renewable resources. Besides it goes in line with governmental interests of providing electrification to rural areas.
This paper provides the information gathered and experiences made from the Mini Hydro Power Project (MHPP) supporting FH development in Indonesia.

1.2 Schematic overview of a MHP installation



1.3 Definitions and terms for small hydropower installations

Hydropower (HP) can be classified by the amount of produced power.

- Mini (MH) < 1 MW
- Micro < 100 kW
- Pico (PH) < 10 kW
- Family (FH) < 1 kW

Such classifications are related to the size of the used turbines. The terms Pico Hydro Power (PHP) and Family Hydro mainly refer to the capacity of the turbines. Whereby PH is “only“ downscaled micro hydro, indicates the term Family Hydro Power a technically simplified type of hydro installation. Its capacity ranges from supplying single-family end-users up to supplying small villages up to 50 households with electricity.
In the following the term Pico Hydro is used for turbines or installations smaller than 10 kW (incl. FH). Family Hydro refers especially to turbines or sites supplying single or small clusters of households (HH) by maximal 5 kW.

1.4 Background

German-Indonesian cooperation on Mini Hydro Power started in the 1990s by supporting private producers developing quality equipment for local electrification projects. Technical design increased in robustness and efficiency and in the meanwhile it reached international standards. The local content in electro mechanical equipment reached already 85 %. This local equipment is 30 – 50 % cheaper compared to imports. Currently two companies export their MHP products to 10 countries in Europe, Asia and Africa.

The Mini Hydro Power Project provides technology transfer, sustainable development and implementation. Indonesian producers and service facilities provide quality equipment and services for local and international markets. This is a sound basis for Indonesia’s growing number of MHP installations.
MHPP supports the market development for rural energy services. Capacity is built to support sustainable MHP project planning and development, operation and management issues and income generating end-use of energy. MHPP works closely with public authorities, private sector engineers, manufacturers, universities and research institutions. To secure sound implementation of hydro schemes for governmental programs of rural electrification, MHPP has built up a network of cooperation and implementing partners.

1.5 Pico Hydro as part of rural electrification

MHPP mainly supports rural electrification via off-grid solutions. It addresses non-electrified households minimally 3 km away from the main power grid. Still such definition addresses various conditions. Some sites are accessible by car others only by feet. Some sites are within hour’s reach of major cities, others requiring a whole day travelling or even more. The villages' sizes can range from several houses up to several hundred. Capacity demand can be 50 W per household or even some kW for “productive use” machinery. Available capacity depends on locally available height drop and water flow, the hydropower potential. This normally specifies the size of turbine, which is chosen.

The process of establishing MHP in a village requires a feasibility research including financial viability, choice and installation of equipment and construction, organisation of local participation during the building process and last but not least local management and operation.
The concept of Pico and Family Hydro focuses on smaller clusters of customers and therefore has some special preconditions compared to MHPs with higher capacity:

- Target areas are more likely mountainous.
- As Family Hydro serves single households the sites are dispersed.
- Access is often more difficult and time consuming.
- Users require electricity initially for lighting and TV.
- Clients usually are poor and often have low education levels.

Such clients, living in small clusters, usually have the least chance to get grid connection due to difficult access and low density in energy demand. Diesel generators, batteries, solar systems (PV), wind or hydropower can provide electricity there. The later is by far the cheapest and most convenient, if the local conditions allow an application.
Family Hydro needs less water and head (height drop) than usual MHP installations. This fact increases the likelihood of possible applications. Furthermore Family Hydro Power reduces requirements in sites design and construction. Planning, construction and operation of Pico Hydro plants is simpler than at MHP plants. This counts even more for the smaller Family Hydro units. Hereby construction can be widely done by local labour. External support comes mainly as supervision and thereby can be minimised.
Due to the far-flung clients the share of external input for distribution of equipment and know-how the number of clients is much higher as it is for bigger villages. This affects producers providing a service and distribution chain to spread their products.

Conclusion: Hilly, mountainous regions have hydropower potential and are mostly the last to be grid connected, due to difficult access. This makes it most suitable for Mini Hydro Power in general and for Family Hydro in particular.

1.6 MHPP – Family Hydro concept

Potential and request for (semi-) individual hydro electrification exists widely in this country. MHPP introduced turbines for such needs. The term “Family” indicates the capacity range of turbines as well as the target customers. Family Hydro turbines operate on relative small amount of water and relative low head. This makes them easier to install, easier to operate and more affordable. Up to now two types of Family Hydro turbines are available in Indonesia. One, the open-flume type providing 100, 200 and 600 W. It can operate with a given height between 1 - 7 m, but needs 10 – 150 l water per second. The other available technology, a Crossflow turbine has a maximum of 2 kW. It operates on 6 – 40 m and needs only 6 – 25 l/s. A crossflow solution with a maximum output of 5 kW is still pending.

Key features of FH turbines are:

- Low price, which ensures affordability.
- Sound quality, which allows operation in remote areas with reduced service and maintenance efforts.
- Turbines' wide availability and simple installation.

MHPP's efforts at Family Hydro since 2007:

- Testing existing commercial "off the shelf" turbines (TC60)
  - Gaining results on robustness
  - Gaining results on applicability
- Importing FH turbines from China
  - Gaining experience on available quality and total expenses
- Testing locally available LED systems as possible FH extension
- Providing public domain turbine design (TP100) which:
  - allows production in small workshops close to target areas
  - supplementing existing FH application range (> 7 m)
  - supporting local producers without distracting competition
- Installing TP100 demo sites
  - Testing efforts for installation and construction
  - Gaining results on robustness
  - Gaining results on applicability
- Providing training material to minimise required professional support
  - Manual turbine production (pending)
  - "MHP FAQs – Frequently asked questions" plus "How to estimate hydropower potential" (in process)
- Ensuring sustainability through social economic training
  - Participation in construction and financing
  - Community organised management schemes according to MHPP standards

To secure the availability of hardware and to overcome difficulties in distribution and services in remote locations of Indonesia's outer islands, MHPP made a free design available for small workshops. However, external know-how is still required to realise a Family hydro site. To reduce external input and to allow clients to increase their share of participation it is needed to supply them with appropriate information material and manuals.

Following material is needed:

- How to judge PH/FH potential.
- How to construct the necessary structures or where to get support.
- Where to get the equipment and possible financing aid.
- How to operate and handle the hardware safely.
- How to organise shared use or energy services.
- How to raise the awareness about productive use possibilities.

Structural support is required to:

- increase accessibility of information and equipment at targeted areas.
- ease access of financial support for clients or electricity service providers.
- create awareness of FH possibilities .

1.7 Family Hydro chances and challenges

Introduction and wide distribution of Family Hydro

Strengths	Weaknesses
▪ cheap, small running costs ▪ renewable energy source ▪ reliable ⇒ long lifetime ▪ small maintenance efforts ▪ independent power source	▪ site specific technology ▪ specific know-how required (feasibility, design, construction) ▪ advance costs (investment) ▪ requires local organisation ▪ difficult access of target areas
Opportunities	**Tasks**
▪ increasing living quality ▪ providing access to modern facilities (lighting, TV, mobile phone) ▪ increasing daily active hours ▪ decreasing basic energy cost ▪ protecting local environment	▪ provide access to remote areas ▪ create regional information hubs ▪ provide hardware access ▪ train local capacities ▪ provide small credit schemes

FH advantages

- Cheapest technical solution for independent power supply.
- Clean and sustainable as it uses renewable energy resources.
- Reliable ➔ long lifetime as it is based upon robust mechanical techniques.
- Minimal running and follow up costs (unlike batteries at PV systems).
- Small maintenance efforts, which are easy to follow (unlike PV electronics).

FH disadvantages

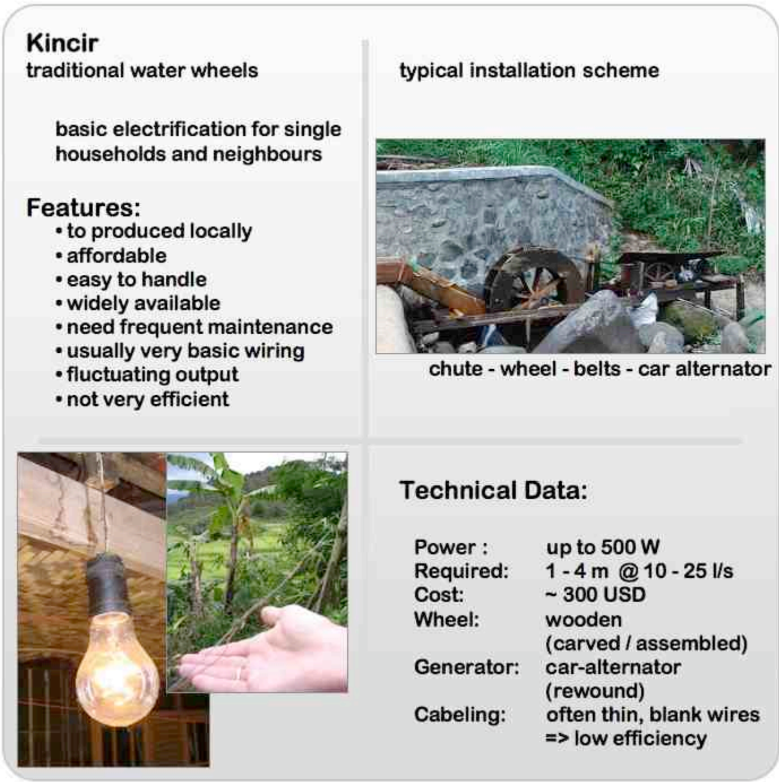
- Site specific power output ➔ pre-feasibility check required.
- Site specific installation ➔ basic hydro know-how required.
- All cost are investment cost ➔ upfront.
- Mostly shared connections ➔ require organisation for operation, management and use of water resources.
- Difficult access of clients ➔ requires hubs and/or supply structure.

Additional advantages if dispersing Family Hydro installations (side effects)

- Decreasing dependency of diesel (saving governmental subsidies).
- Direct budged savings by equipping far-flung government offices through FH generated electricity (instead of diesel gensets or PV systems).
- Combining FH with other independent power producing solutions can reduce costs significantly and therefore increases efficiency of rural electrification programs instead of providing complete villages with solar home systems.
- Reducing usage of one-way batteries and kerosene (for lighting) and its negative environmental impacts.
- “Preparing the field” for Micro and Mini Hydro installations via demonstration effects.

2 Family Hydro Compendium

Indonesia provides suitable natural resources for Pico Hydro Power. The need for electrification at rural areas is there as well as the general capacity to handle hydropower technology. Production capacity for Pico and Family Hydro systems has also built up in he past.



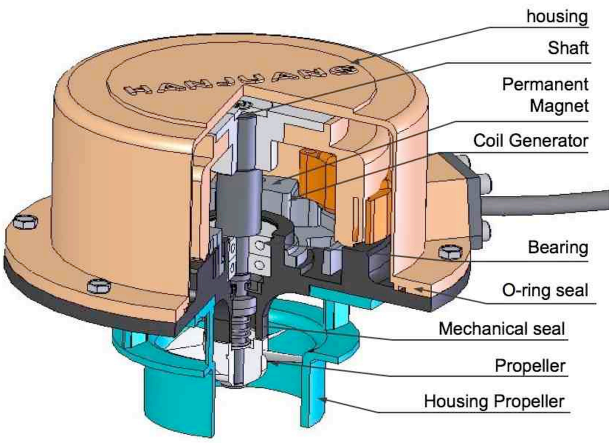
MHPP's approach 2007/08:

- Raising awareness of local partners towards Family Hydro solutions.
- Testing and introducing existing equipment.
- Researching demand, potential target areas, cooperation and supportive models, ability.
- Developing new equipment for rural workshops.
- Introducing demonstrative Family Hydro schemes.

2.1 TC60 - Family Hydro

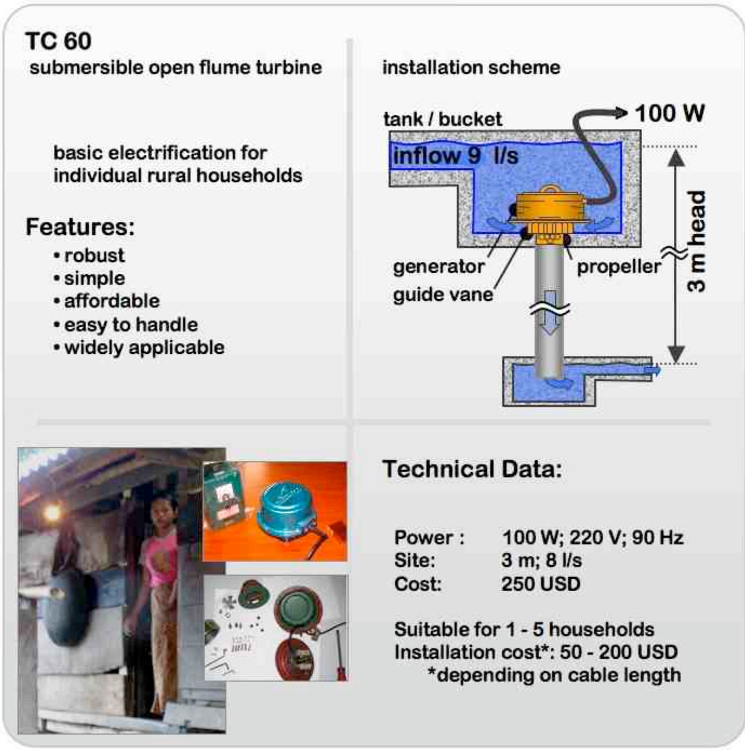
2.1.1 Background

The concept of affordable individual electric power supply in remote areas is appealing and proved to be very successful in Laos, Cambodia, Vietnam and parts of China. CIT in Bandung developed the "TC60" inspired by Vietnamese/Chinese low cost Open Flume turbine (OF turbine) design. Sales started at the beginning of 2007. With a price less than 300 USD makes TC60 an option for private energy supply for single households. It produces 100 W at site specifications of only 3 m head and a flow < 10 l/s. Total installation cost depend on cable length from turbine to house. (50 USD/ 100 m)



With available locally produced hardware, MHPP evaluated possibilities for wide distribution in Indonesia. Before testing TC60 under field conditions, there had to be certain safety standards to be accomplished as a precondition.

2.1.2 Intention and approach



The Dutch government decided to pilot the implementation of Pico Hydro solutions aiming to electrify 6,000 people. With TC60 from CIT a market approach was considered to enable a wide distribution in rural areas most quickly.

In order to safeguard a sustainable distribution, some measures were taken. For consumer's safety, some technical applications where improved, then MHPP tested 8 TC60 turbines regarding applicability for wide distribution under field conditions. This took place in close cooperation with producer and partners at the target areas.

These setups where also used to elaborate demand from potential customers. Currently TC60 proved stabile but costly for private consumers. Distribution from producer towards the outer islands is limited and service or spare parts are difficult to get there.

2.1.3 Partners

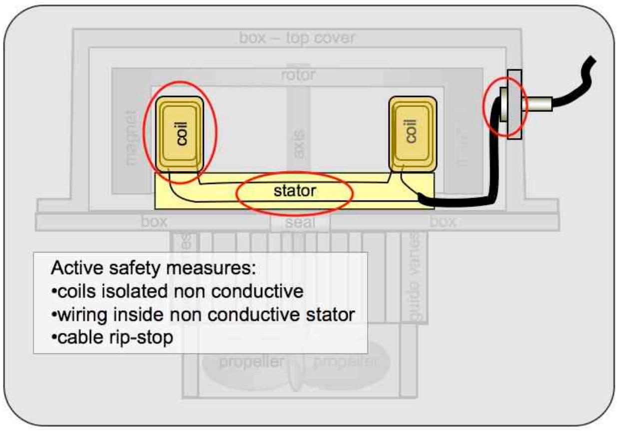
- CIT
  Pak Eddi runs a MHP workshop as well as an instant coffee factory in Bandung/Java. He is a genius promoter. During the time of TC60 introduction there was very much MHP business going on and resources where shifted according to potentially easy revenues. The concept of safety feature where followed, but went only partly into the series production. The needs to establish a distribution and service chain towards remote markets were considered as to expensive respectively too risky and done very carefully. Turbine sales peaked in May 2007 and decline from that point. Many TC60 units where given as example together with big turbine orders. Still, now there are 5 - 10 turbines produced per month and the total number produced is around 500.
- ProWater
  Pak John and Pak Enoh do MHP implementations and basic turbine manufacturing in West Sumatra. ProWater took two TC60 units in August 2007, where one was installed in Tolong Lao.
- Pak Linggi
  Pak Linggi runs a small turbine workshop in a small village in Sulawesi Barat, where he is also head of the village. By establishing a local MHP hub in the region around Sumarorong he managed to supply his whole "desa" (village) fully with hydro electricity. Since March 2007 he operates a TC60 at his place for demonstrative purposes. During 2007 and 2008 he installed another 5 units for MHPP in remote locations around the region.
- Pak Ferdi
  Experiences in implementing MHPs he started a small MHP workshop in August 2006 in Tana Toraja/Sulawesi. He was applying and capable of implementing some test units but it is still pending.

2.1.4 Measures

Increased safety features of TC60

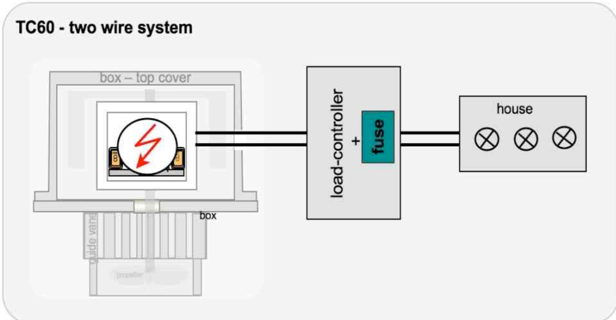
Since the turbines operate under water, potential shortcuts can lead to serious injuries. Therefore at least a minimum safety level had to be ensured at first. Improving safety was done actively by hardware adjustments and passively by information and training of consumers (manuals).

These measures where applied only for the turbines that were ordered for the MHPP tests. They did not fully become production standard, because neither the producer nor potential customers where willing to accept higher efforts (production or money wise).

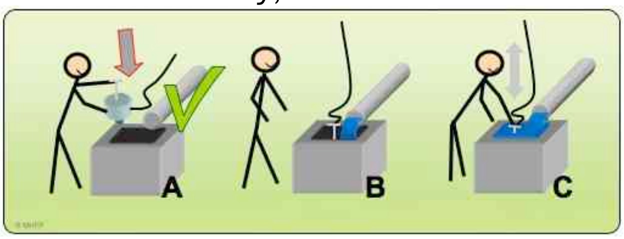


<u>Active safety measures initiated:</u>
Insulating electrical parts inside the turbine box, by separating it mechanically from the aluminium cover. This included a stator from non-conductive material, cables placed inside non-conductive stator and measures to ensure stress relief of the power cable led through the box. It was also assured that the used outlet cable is certified waterproof.

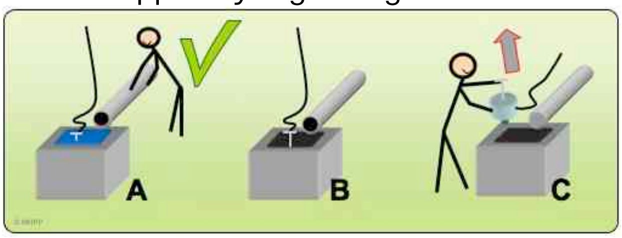
To reduce cost of required cables, a pragmatic concept led to the decision of a two-wire system, which is safe even against contact of conductive parts as long as there is no second contact against ground within the system. Ground-Fault-Current-Breakers are to expensive to be used and require proper grounding which cannot be assured to be applied in the field. Cost and practical reasons led to the decision to leave away mechanic current breakers (MCB) as well.



<u>Passive safety measures initiated:</u>
Operating an electricity-producing unit in wet environment is still dangerous. The usual small internal generators works on a permanent magnet, so there will be voltage immediately if there is any movement. Absolute safety during using the turbine can be only given if its handling is appropriate. The most effective way to ensure this is to provide a suitable manual with it. MHPP provided an extensive draft for a TC60 consumer manual, including chapters of "How to handle electricity, construction and installation". The producer did neither translate into Indonesian nor apply.
For absolute safety, turbine should be started and stopped by regulating the water inflow.



Starting TC60
A putting turbine into tank
B opening water
C lifting the turbine slightly



Stopping TC60
A stopping water flow
B till tank is empty and turbine stopped
C taking out the turbine

Field tests

Tests showed a turbine efficiency of 40 %. The low figure mainly results from guide vane and propeller design. The propellers low efficiency is due to simplified production process. MHPP asked its partners for potential locations to install the TC60. Ideally these were located close to an existing MHP. So MHPP handed the turbine over to the MHP-management, which provided local know-how on MHP for local assistance.

During the field tests information was collected regarding:

- mechanical quality of turbines.
- applicability in the field (installation, repair).
- interest and need assessment.

The information was used to elaborate

- turbines acceptance (cost-use).
- requirements for wide distribution.
- possibilities of combination with LED lighting.
- possibilities of combination with CFL lighting.

2.1.5 Test results and experiences

Sites where TC60 installations are monitored:

Island	Site	Partner/ User	No. Unit	No. HH	Date installed	Latest visit	Status
Sumatra	Talaok	ProWater	1	2	08.07		little flow
Sulawesi	Batang Uru	Linggi	1	-	04.06	09.07.08	n.op.
	Nene Ramba	Dae	1	1	02.08	09.07.08	op.
	Kollong Lau	Anga	1	1	02.08	09.07.08	op.
	Kollong Lau	Suleman	1	2	05.08	09.07.08	op.
	Batang Uru	Linggi	1	5	08.08	01.12.08	op.
	Batang Uru	Linggi	1	1	08.08	01.12.08	op.
	Batang Uru	Linggi	1	1	08.08	01.12.08	op.
	Patanyaman	Nasrudin	1	2	08.07	05.07.08	partly op.
Total			9	15			

op. = operating n.op. = non operating

All users pay monthly fees to the local MHP organisation. Tariffs vary and, due to lower capacity, normally lay below other connection fees within the same area. Usually the turbine is operated only at night for lighting purposes.

Field applicability technically

- TC60 proved to be robust and applicable.
- The provided 100 W cover basic electricity need of one household easily.
- Power output is sufficient for up to 5 households (lighting only).
- The turbine is not flexible in height/flow requirements. If applied under 2.5 m it becomes difficult to start. This results from the internal 2-pole generator.
- The installation and adjustment of the load controller is not self-explaining.
- Final safety status depends mainly on local know-how and awareness (passive safety measures).
- Suitable sites are often not close to the house. This requires long cables which are relatively expensive (50 USD/m).

➔ The concept of such a turbine for individual use is most promising in terms of wide distribution for remote areas. An extensive manual could reduce some of the technical shortcomings.

Field applicability consumer wise

- With 250 USD for a turbine controller package and cable of 50 USD/100 m, costs of turbine are comparable to a “kincir” installation (waterwheel) or even cheaper.
- Judging site feasibility is difficult for laymen (especially the flow rate).
- Installation possible by laymen.
- Without professional assistance customers need extensive (maybe graphically supported) manual for feasibility, construction, installation and organisation (if connection is shared).
- If once installed, operation is simple.
- Investment costs are in rage of a farmer’s yearly income from agricultural products. This hinders a "cash and carry" sales concept and requires long term financing schemes, if based on purely commercial sales.
- Cabling can easily become a big cost factor.
- Far-flung hamlets are mostly the poorer ones and therefore no potential customers for a “cash and carry” approach.

2.1.6 Recommendation

TC60 is a product from CIT. MHPP provided technical suggestion, which proved applicable in a series of test turbines. A draft for an extensive manual for TC60 was provided as well, but lacks its finalisation in Indonesian language and some company specific details. Application at CIT is still pending.

➔ Distribution of the turbine, as it is sold at the moment, requires a local partner for instructions. It is very suitable for single cases, who can afford the investment cost. It can be a cheap solution to supply remote offices, schools or other public services. Within rural electrification projects TC60 can provide a cost efficient solution for houses more than 650 m away from the village power line.

Information material

- Finishing an extensive TC60 manual, which should be provided with the turbine. Such can be used also as informative brochure. This would allow potential customers to check for suitable sites in advance and ease the feasibility process required in advance of the installation.
- Creating explanation material suitable for potential customers, how to build a trash rack, tank and outlet or providing simple readymade solutions.

Technical features

Further quality improvement allows targeting a wider or even international market. By increasing range of applicability more locations and customers become viable. By increasing quality the need and effort of field services will reduce.

- Ensuring functionality under part load by using different generator magnets.
- Providing standard frequency 50 Hz instead of 90 Hz by changes in generator design.
- Change to robust ballast (e.g. thermal resistor).
- Increase efficiency from 40 % to ~60 % by different propeller and guide vane.
- Controller box should be splash water resistant.
- Suitable (spare) fuses have to be provided (0.5A).

Distribution

- Turbines availability, features and requirements should be known to respective bodies and local governments.
- Sales require distribution and service structures in remote areas. A required stock of turbines and supervision of local personnel will be costly. For a try it is useful to focus on certain target areas.
- Credit services could buffer the high investment for potential private clients. Such would have to be available locally and relative long payback periods. The turbine itself could be a safety asset.
- Support of small “energy providing businesses” or merchants could cluster the “experience” needed for site feasibility estimation, installation, or at least for explanations of handout material.

Effort estimations for product improvement towards “export quality”

- Generator improvement: 1 – 3 months incl. testing
- Efficiency increase ~ 20 %: 1 – 2 months incl. testing (guide vane and propeller)
- Manual: 1 month incl. design (incl. chapters on construction)
- Trash rack design: 1 month incl. field test

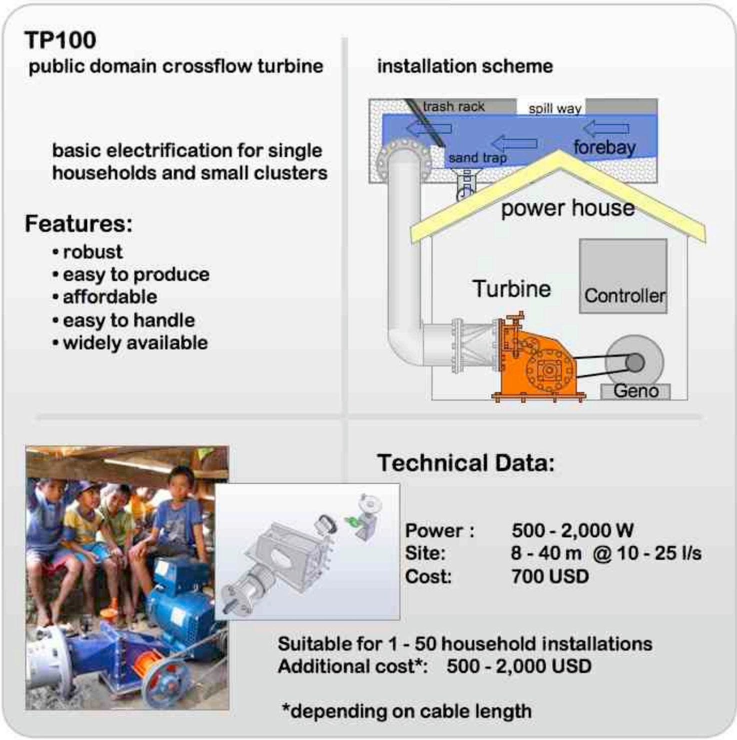
2.1.7 Situation, outlook and chances

Currently there are about 500 units of the TC60 distributed. Most of them were given to customers of bigger hydropower units as an add-on for promotion purpose. Pure business sales are still quite limited keeping only two people busy with production at CIT. There are no attempts to increase efforts on this turbine. Mainly as further development in quality is not considered as useful (“it already works”), secondly as further dissemination would require service structures, which can become costly and difficult to establish and hold. To gain substantial revenue on small turbines, needs sales in big numbers. This usually requires higher standards on quality and higher efforts in pre-investment. To have a range of turbines available to suit a wide range of site conditions makes a concept of wide market introduction much more flexible and effective. There are bigger siblings of TC60 available at CIT (see also 2.4.2 CIT Open Flume turbine - Range overview).

The existence of traditional waterwheels indicates the demand of individual Family Hydro clearly and also shows that a technical capacity of handling even exists on village level. Individual Family Hydro can become widely spread in Indonesia on a market basis, if distributors can make turbines locally available and can offer ways to reduce the high investment costs for the final customers and if a producer is willing to make the current design slightly more flexible in applicability.
A turbine for 5 – 50 W requiring only little water and height resources could be much cheaper. It would be a unit for private primary electricity supply. For estimated production costs < 50 USD for a basic version (see also 2.4.1 MHPP Turbines – Overview, Tpocket).

2.2 TP100 - Public domain turbine design

2.2.1 Background



Earlier experience under MHPP (2001) in distribution of Pico and Family Hydro technology showed high demand, technical feasibility but difficulties in making the equipment at site available. Downscaled T14 turbines at Heksa (ø 150 mm) or the aluminium cast “Piccolo” from CIT did not find sufficient customers within the last 5 years to be produced over a period of time.
Centrally located producers struggle with the task of building up distribution and service networks for Pico/Family turbines. Projects with higher capacity usually gain also higher revenues than small hydro sites. Due to low density of clients and low governmental interest/support potential winnings are too small, that a focus on Pico turbines would be preferred over the “standard” Mini and Micro Hydro business. Effort and risk of investing in distribution and service infrastructure are too high for the established producers, especially before a critical mass of demonstration turbines is installed or revenues via programs or constant interest can be predicted. To tap the huge potential market for centralised Pico and Family Hydro, producers require pre-investment in supply structure and/or massive simplification of the installation process to reduce installation efforts.

2.2.2 Intention and approach

Intention

To shorten the distance between producer and target areas, MHPP activates production capacities all over the country to produce and distribute TP100 more locally. Local demand can so be supplied by local facilities. This reduces distribution efforts and ensures availability of services. Utilising existing production, distribution and implementation capacity in remote areas requires a design, which is freely usable and does not require sophisticated machinery.

Concept

MHPP supplied partners in focal areas in Sulawesi and Sumatra with the design of a turbine to be produced with relatively simple tools and little experience in turbine building. The design ensures basic quality and efficient use of resources.
Supporting installation of some demonstration schemes raised local awareness as well as provides the small workshops with first hand experience. As the workshops will be responsible for the installation as well, instalment of such small units can also be financially viable in remote places.

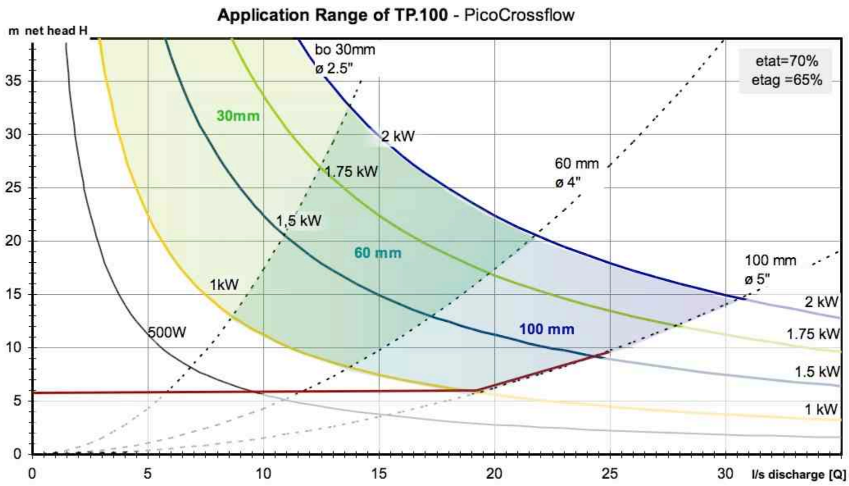
Approach

MHPP designed the TP100 and distributed examples to partners in Sulawesi and Sumatra. In Sulawesi are already two units installed and further ones planned. The producers will also get an order to produce a TP100 on their own if they can find a suitable site for it and organise its installation. By this procedure no pre-investments from the workshops are required, as the turbines will be produced on order. How the process will speed up and more orders will follow depends also on actual request for this kind of turbines.

2.2.3 Technical data and design features

Technical data

Output: 500 – 2,000 W
Site requirements: 40 m with 5l/s or 8 m with 25 l/s



Height and water discharge at site define the turbines power output (coloured lines: 500 W – 2 kW). There are 3 different widths of TP100 to choose (bo 30 mm, left; bo 60 mm, middle; bo 100 mm right) to suite the respective conditions. TP100 is designed for a maximal power output of 2 kW. Below 6 m head TP100 is not feasibly applied.

Productions costs will range from 500 – 700 USD.
Suitable Chinese generators are available for 250 USD.
Total installation cost: will depend on site conditions:

- Penstock cost ~ 25 USD/10 m
- Transmission cable 50 USD/100 m
- House electrics can be estimated with 10 - 20 USD / HH

Design features

TP100 is especially designed to be produced at small workshops, which shows in:

- reduced number of single parts (compared to T14 turbine).
- only requires drilling, lace, welding machine for production.

For easy handling in remote rural areas TP100 design provides:

- easy access to runner for eventual cleaning.
- manual flow control to allow operation without electric load controller.
- application range for little flow so the required civil construction is smaller.

MHPP can provide a “TP100 package”, which includes:

- manual for manufacturing (in process).
- information leaflet which introduces basics of MHP to villagers.
- manual for dis-assembling.
- brochures for management if a number of users is connected (“blue books”).
- detailed manual on feasibility, construction, installation and operation is still pending.

2.2.4 Partners

- MHPP staff:
  TP100 is invented by Gerhard Fischer, Yudistira Christika made drawings and mechanical design, Pak Jajang and Pak Herman produced the prototypes, Mas Iwan did the first test series in TEDC hydro lab, Tim Chiaradia managed the process.
- CIT, Kramatraya (Addresses see Annex) were the established workshops producing the first TP100 units in width of 30, 60, 100 mm. From there MHPP improved further turbine details.
- Pak Linggi, ProWater, Pak Ferdi will be the first producers on the outer islands to implement the TP100 turbine into their product portfolio.

After minor detail reviews since January 2009 the design is in a stage where it can be handed out to interested workshops or institutions.

List of workshops who got the drawings. To be asked for feedback and experience:

No.	Name/ Company	Location	Use
1	Pak Linggi 085825059681	Sulawesi, Batang Uru	Production (pe), Installation
2	Pak John, ProWater	Sumatra, Padang	Production (pe), installation (pe)
3	Pak Alfi 081320321556	Java, Bandung	Production, installation (pe)
4	Pak Eddi, CIT 081322221158	Java, Bandung	Production
5	Pak Heri, Kramat 08122337576	Java, Bandung	Production (pe)
6	Pak Kus, Heksa 08122376787	Java, Bandung	Production
7	Binyam Abate, University	Ethiopia, Addis Ababa	Research, production (pe)

* when the drawings were given/updated pe = pending

2.2.5 Measures and measurements

Measurements on TP100 efficiency are still ongoing at TEDC institute in Bandung. First results indicate relative low turbine efficiency of about 50 %. If systematic mistakes from measurement procedure occurred or if turbine design has to be revised is still open. Contact persons towards TP100 testing at MHPP are Gerhard Fischer, Yudistira and Iwan.

The approach to supply a FH design for rural workshops was followed by the measures taken. The TP100 drawings, welding-cheeks and example turbines are sent to the workshops on the outer islands. There, demo installations are proposed first to allow the partners to gain experience on this specific turbine. If the local entities see other suitable sites they will be contracted via MHPP to produce TP100 locally.
Up to December 2008 two installations in Sulawesi were completed. In close cooperation with the villagers, one was done by Pak Linggi in Salulombe, the other one by MHPP staff in Garumpalo (Garumpar).
Both installations worked out fine, despite minimised external input focussing on visits to explain principle of FH and basics where and how to do the construction work. It indicated that a concept of small cluster electrification by Family Hydro eases participation and therewith installation as a whole.

2.2.6 Results

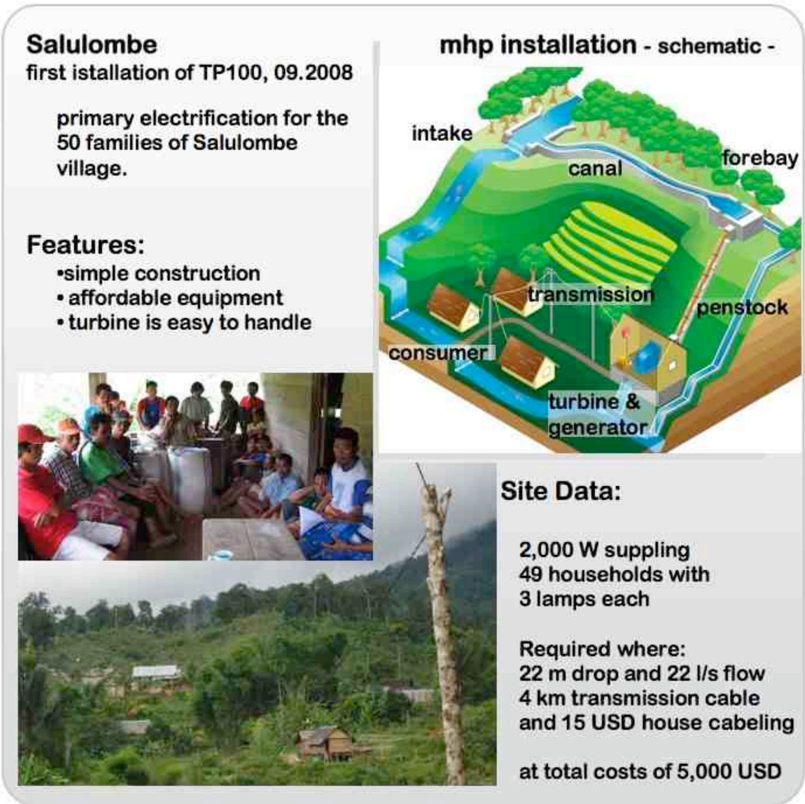
Consolidating numbers of first two test sites in Sulawesi (status 12.2009)

	Salulombe	Garumpalo
Power output	2 kW	800 W
Number of HH	49 (only lighting)	9
Total cost	5,000 USD	3,000 USD
Inauguration	09.2008	09.2008
Duration construction	3 months	2 months
External visits	~ 5	2
Turbine	TP100, bo 60 mm	TP100, bo 100 mm
Manufacturer	Kramatraya, Bandung	Kramatraya, Bandung

see also: Fact sheet Salulombe and Garumpar

Overview

Family Hydro scheme has the same elements as a Mini- or Micro plant but they're simpler. TP100 – electro mechanical equipment comes for less than 1,500 USD (incl. ELC).
Since MHPP spread the word, there is a lot of interest regarding ordering or even producing TP100. Due to the limited size and limited costs this turbine allows relative simple site constructions. The participative share on construction, installation and management can be very high with only small external input. It reduces expenses and (external) efforts. Typical material costs are 2,000 USD + 50 USD/100 m transmission cable.



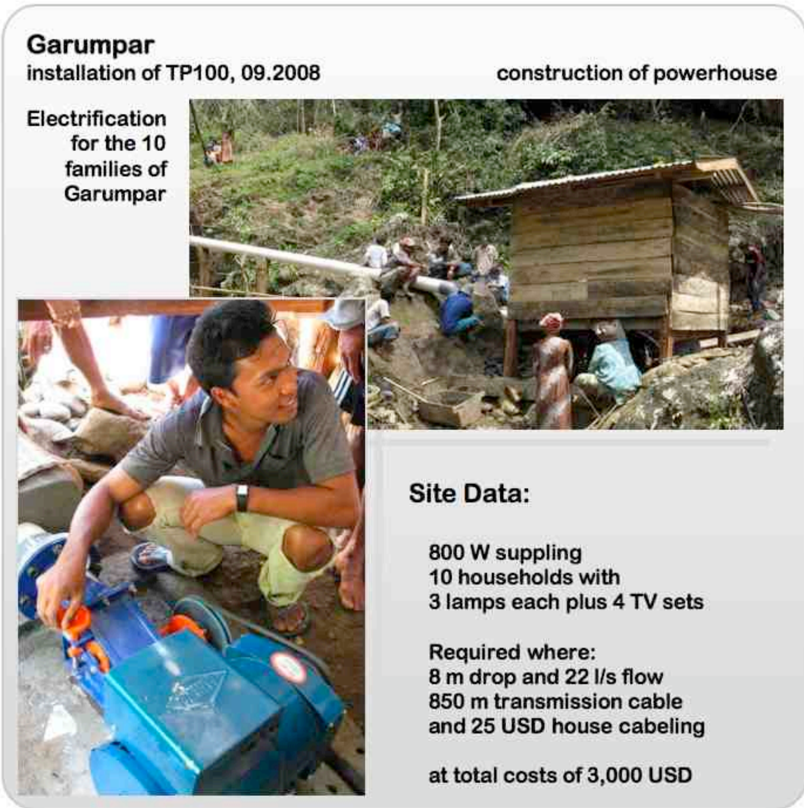
Challenges, experiences, outcomes

- To keep costs at bay the construction should be made by local manpower. Different stages of the installation process require some days of professional advice. Speed and accuracy of progress depends on people involved. It is important that villagers develop ownership for their hydropower site.
- Installation of flush gates or cleaning pipes in sand trap and forebay is often neglected.
- Width of trashrack should be max. 1 cm.
- Penstock and adapter have to be installed before turbines base frame.
- Precise alignment supports standing time of turbine and generator bearings as well as pulleys lifetime. How to inspect the both axis parallelism during alignment has to be explained in detail.
- The consequent use of CF-lamps increases the available capacity enormously. Its use is best introduced from the beginning.

Potential sites/follow up installations

To introduce the TP100 concept towards potential producers or implementing entities MHPP will provide electro mechanical equipment for potential sites in respective target areas.

- Mambi/Pak Maswedi (Komarudin, February 2009)
- Pak Alfi (March 2009, pending) http://pikohidro.wordpress.com
- ProWater (Komarudin, February 2009)
- Dewata (Gerhard Fischer, pending)



2.2.7 Recommended follow ups and open questions

Backstopping of primary TP100 introduction

- Further installations at potential sites (see above).
- Monitoring of existing sites.
- Introducing production at rural workshops (Pak Linggi, ProWater, Papua (?)).
- Building up awareness on FH possibilities for regional entities (manuals, trainings).
- Elaborating an extensive Family Hydro package (see below).

Further utilization of Family Hydro concept

With a set of information material and manuals the TP100 concept could be used to train producers, implementers, villagers on the topic of Micro hydropower. It covers most required information and can serve even as “starting kit” into MHP programs in general.

Such a package would include:

- TP100 design drawings (available)
- Technical manual “How to build TP100?” (in process)
- Poster “What is Micro Hydro Power?” (in process)
- Manual “How to judge Micro Hydro or Family Hydro potential?” (in process)
- Scout book MHP (available at AMES-E, March 09)
- Design- and construction basics of FH infrastructure: weir, intake, canal, forebay, penstock, powerhouse and transmission line (concept)
- Manual of TP100 and generator installation, alignment, and operation (concept)
- Manual on TP100’s operation, maintenance and safety (concept)
- Materials for tariff setting, management and organization (concept)
- Materials on “Possibilities and productive use by electricity” (concept)

A local service hub, trained to supply support to above-mentioned topics, would minimize external support for feasibility check, construction check, installation and inauguration.

The creation of such a Family Hydro package would primary allow the distribution of increased numbers of Family Hydro turbines by minimised external inputs. This package can be used as introduction or addition in and onto Micro hydropower projects, to test certain target areas on participatory feedback or to validate new MHP implementation approaches.

Open questions

It is required to clarify on legal status, procedure and requirements of an “licence free” concept like this. Furthermore it is unclear how the counterpart, who is the official responsible, will handle these issues.
The handing out of drawings ideally would include track keeping to allow feedback and additional information on potential further development (see table under 2.2.4).

2.3 LED battery lighting

Lighting is the first utilisation of electricity and often requires the biggest capacity share of a Family Hydro site. Efficiency of lighting allows efficient use of Family Hydro equipment. MHPP tested if LEDs advantages like very low energy demand, robustness and very long lifetime can be utilised at village level.

Setup:

To increase utilisation from limited power sources (FH), LED lighting was tested. The available system, assembled in Indonesia from Solare, used LED lamps to be operated from a standard 12 V motorbike battery. Users have to recharge the battery in intervals of several days.

Hardware specifications: 3 - 5 LED lamps with total power of 3 Watt; battery: unprotected 7.5 Ah, sealed; system cost: 50 USD

Questions to get answered:

- Is LED lighting sufficiently strong?
- Is the lights temperature (colour) acceptable?
- Is a concept of chargeable battery driven lighting accepted?
- Is the organization scheme for a charging setup easily installable?

Approach:

MHPP provided at some villages, where Mini Hydro Power management existed, with LED battery units for local installation.

The local MHP management (UPT) ensures proper installation and operation.

The LED battery installations work as test and demonstration units to prove and promote rechargeable LED lighting installations. The systems are provided free of charge to the UPT if installation and maintenance is ensured and tariffs are collected.

Requirements for test households:

- Charger in walking distance
- No grid connection available
- Located within the UPTs responsible area (tariff collection, maintenance, monitoring, charging)
- 12 V battery charger was provided to the local UPT.

Outcome:

- Acceptance in rural areas depends strongly on available alternatives. At one location the reasons of rejection were: no possibility to operate TV and the need of recharging the battery. Other installations did not have such complains, there the systems are still in operation.
- Light colour or too little light output was from no concern.
- Battery driven lighting is feasible and widely accepted (where the units were used to supply houses in the village too far from the grid to be connected).
- The interest of multi-lamp-LED-systems is high.
- Typical charging intervals: 5 - 7 days,

- Technical quality:
  Laboratory tests at Fraunhofer ISE/Germany showed a high grade of light output degradation. Solare changed their LED supplier. Whether the quality is better is difficult to prove. Solare's approach to eliminate additional electronics as far as possible targeted increased system lifetime. It may also be a reason why the LEDs degrade relatively quick. LED lifetime is roughly 1 year on constant operation (~ 50 % degraded).

Conclusion:
LED lighting is energy efficient and robust (theoretically) and therefore ideal for rural lighting. It can boost use of FH, PV or even be used by rechargeable batteries if an electric source exists in walking distance. So far house lighting systems using LEDs with long lifetime (~ 10 years) are still too expensive to be competitive. Future development will bring down the costs significantly within 2 - 5 years.

Island	Site	Partner/User	No. Units	No.HH	Date installed	Status
Java		MHPP	2	2	07	i.o.
Sumatra		ProWater				?
Sulawesi	Patanyaman	Nasruddin	2		07	o.o.
	Batang Uru	Linggi	5			
	Leke	Kareu	1	1	07/08	i. o.
	Menanga	Anga	1	1	07/08	i. o.
	Rate (new)	Konstantina	1	1	07/08	i. o.
	Rate (new)	Zacharias	1	1	07/08	i. o.
	Tabone	Meri	1	1	07/08	i. o.
Total			9	7		

o.o. = out of operation i.o. = in operation

2.4 MHPP Family Hydro materials

Wide spreading Family Hydro for energy supply can be achieved via various approaches. The different actors are usually: the villagers, governmental bodies aiming for rural electrification, hardware producers as well as merchants or energy service utilities. The specific situation of a target area may require different methods.
Approaches feasible in rural Indonesia are community owned and managed plants, or electrification by service providers, who gain revenue from tariffs.
Cash and carry, renting or leasing may only be possible if credit schemes are at place. Else the investment capacity of rural inhabitants is usually not strong enough.

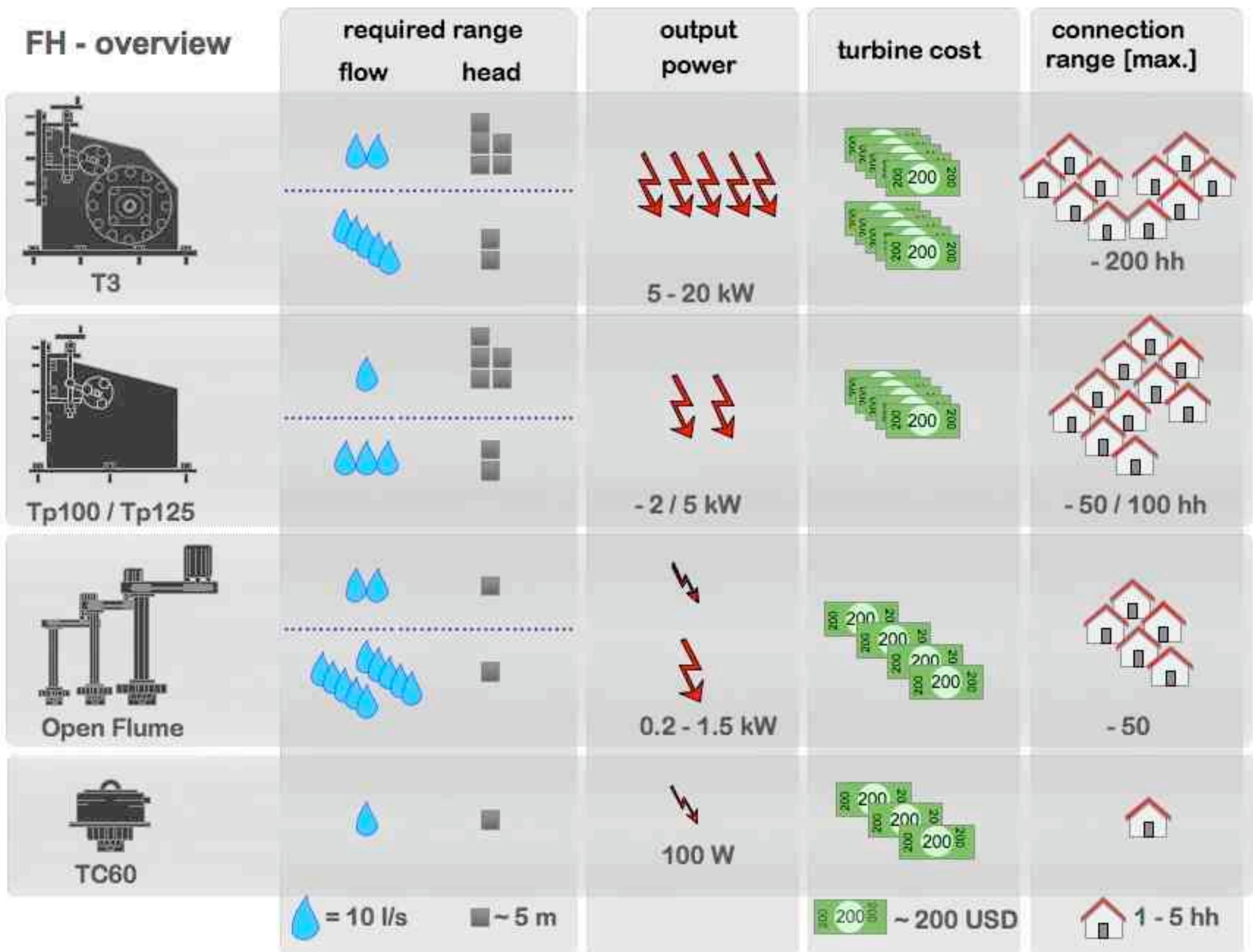
2.4.1 MHPP Family turbines - Overview

Pico Hydro serves a wide range of site conditions whereby different power potentials ask for different types of turbines. MHPP works on a range of Pico turbines. Stages of completion reach from concept status up to finished products.

	Power	Features	Contact	Status
T3 crossflow	-20 kW PH	simplified, free design for rural workshops, easy to open (cleaning), robust and efficient	GF/Yudis	in process
TP100/TP125 crossflow	-2/-5kW FH	simplified, free design for rural workshops, easy to open (cleaning), robust and efficient	GF/Yudis/Tim	available, eventually improving efficiency
sPaT - submersible Pump as Turbine	-500 W FH	using std. submersible pump with new runner, waterproof, high	GF	design phase, generator design

		safety standard, mass product -> cheap (< 100 USD), for individual power supply		pending
TC60 propeller	-100 W FH	individual power supply, low head, waterproof, made in Indonesia	Eddi/Tim	available, improved design suggested
OF 100 – 200 mm propeller	-1.5 kW FH	individual power supply, low head, made in Indonesia	GF/Yudis/Tim	available, improved design suggested
TPocket propeller	5 – 50 W FH	individual primary power supply, widely applicable due to minimal flow and head requirements, mass product, complete package cost including lamp < 50 USD (aimed).	GF/Yudis	in process, generator design pending (Solare)

A quick overview on MHPP Family Hydro turbines:



2.4.2 CIT Open Flume turbine - Range overview

propeller diameter	200 mm	125 mm		60 mm (TC60)
head [m]	1 - 3	1 - 4		3
debit [l/s]	40 - 95	15 - 45		8.5
power [W]	200 W – 1.5 kW	84 W – 1.0 kW		100 W
Price [100 USD] ~	7 (600 W) 10 (1 kW)	6.5 (500 W) 9.5 (1kW)		2

MHPP did not yet start systematic tests on CIT's OF series. It is expected to gain efficiency increase of 10 - 20 % by improving guide vane and propeller. There was no closer research on quality of bearings, sealing and controller. An extensive installation and operation manual would be required too.

2.4.3 Manuals and info materials

Manuals and materials for clients in rural areas play a crucial role for wide dissemination of Family Hydro. Various manuals exist on MHP but are mostly targeting professionals. The task will be to elaborate a set of materials to be distributed to potential clients. Requests for support will be much more accurate and more feasible if the clients will have already a basic understanding of Micro Hydro principles. To reach certain quality from participatory works, the clients need to know the basics in civil construction as well as function and design of hydropower specific elements like trashrack, sandtrap and penstock.

- Turbine related manuals/drafts
  TC60 manual draft (translation, review)
  TP100 manual draft (pending)
  TP100 OP (pending)
  TP100 dismantling sheet
- Available manuals for feasibility studies
  MHP-FAQ (in process)
  HP scout-book (pending – Ethiopia, AMES-E)
  Droplet leaflet (permission requested from Nigel Smith – no answer)
- Available material for management
  MHPP management books (Indonesian and English)
- Material for monitoring
- TP100 check-up sheet
  Monitoring sheet (simplified)
  Site monitoring reports ➔ see Annex

3 Conclusion

MHP provides an ideal solution for rural electrification in Indonesia. Family Hydro targets especially areas with lower power range and small clusters of households. This increases the number of feasible sites massively. Procedures for implementation 100's of MH sites via local empowerment proved to be successful. Local FH turbine production strengthens a regional market. This reduces material costs and increases access to hardware and related services. Capacity building minimise required external input and costs on the long run. Potential players can be provided by basic local hydropower know-how on: MHP principles, required conditions, civil construction, local management and operation. External technical support focuses on providing suitable technology, supervising installations, maintaining quality levels and ensuring sustainability e.g. by networking between different villages.
Next to its obvious outcomes, Family Hydro Power nicely serves as exemplary utilisation of hydro potential. Its participatory share can be higher so local commitment and ownership is usually much higher and therefore the installation most durable. A certain density of installed Micro Hydro systems in a region establishes enough experience and confidence to activate a commercial hydropower market. Thus would allow even bigger numbers of installations on reduced external efforts. To achieve that requires time, time for all the participant to learn, become used and experienced with the available solutions. This counts for villagers, implementers, trainers, facilitators and producers. Patience, persistency and Family Hydro Power will serve wide areas of Indonesia's outer islands.

4 Annex

4.1 Online and digital resources

4.1.1 Project description and materials

MHPP hompage: http://www.mhpp.org
Internet portal on Mini Hydro Power: http://www.microhydropower.net/index.php

4.1.2 Case studies and manuals

http://www.eee.nottingham.ac.uk/picohydro/documents.html#casestudies
http://www.hedon.info/CommunityPicoHydroKenya

4.1.3 Family Hydro resources

Digital bundle containing:

- Fact sheets
- Info boxes
- Manuals drafts
- Reports

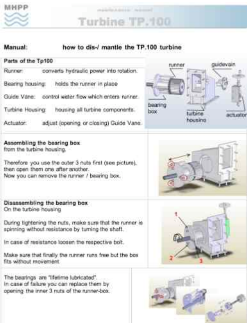
4.2 Manuals and Fact sheets

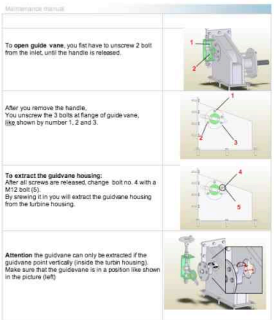
4.2.1 Consolidating material of test sites (status 01.2009)

- Fact sheet Salulombe
- Fact sheet Garumpar
- Fact sheet Tp100
- Fact sheet TC60
- Fact sheet LED-Brochure draft

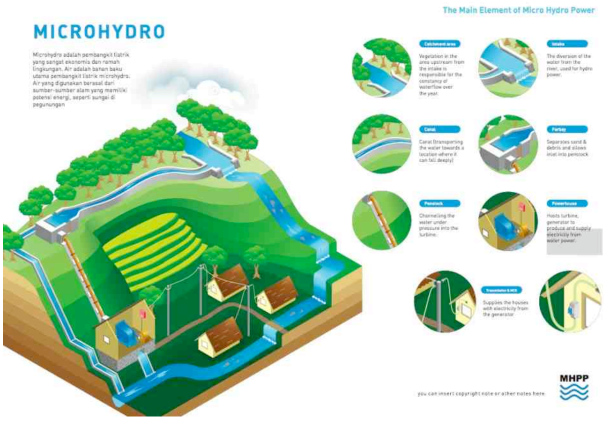
4.2.2 Manuals and brochures

- TP100 maintenance manual (technical)





- “Micro Hydro Power scheme” (general leaflet)



- “What is Hydropower?” – Frequently asked questions (info poster)

(01.02.09 - Draft)

4.3 Addresses of partners and producers

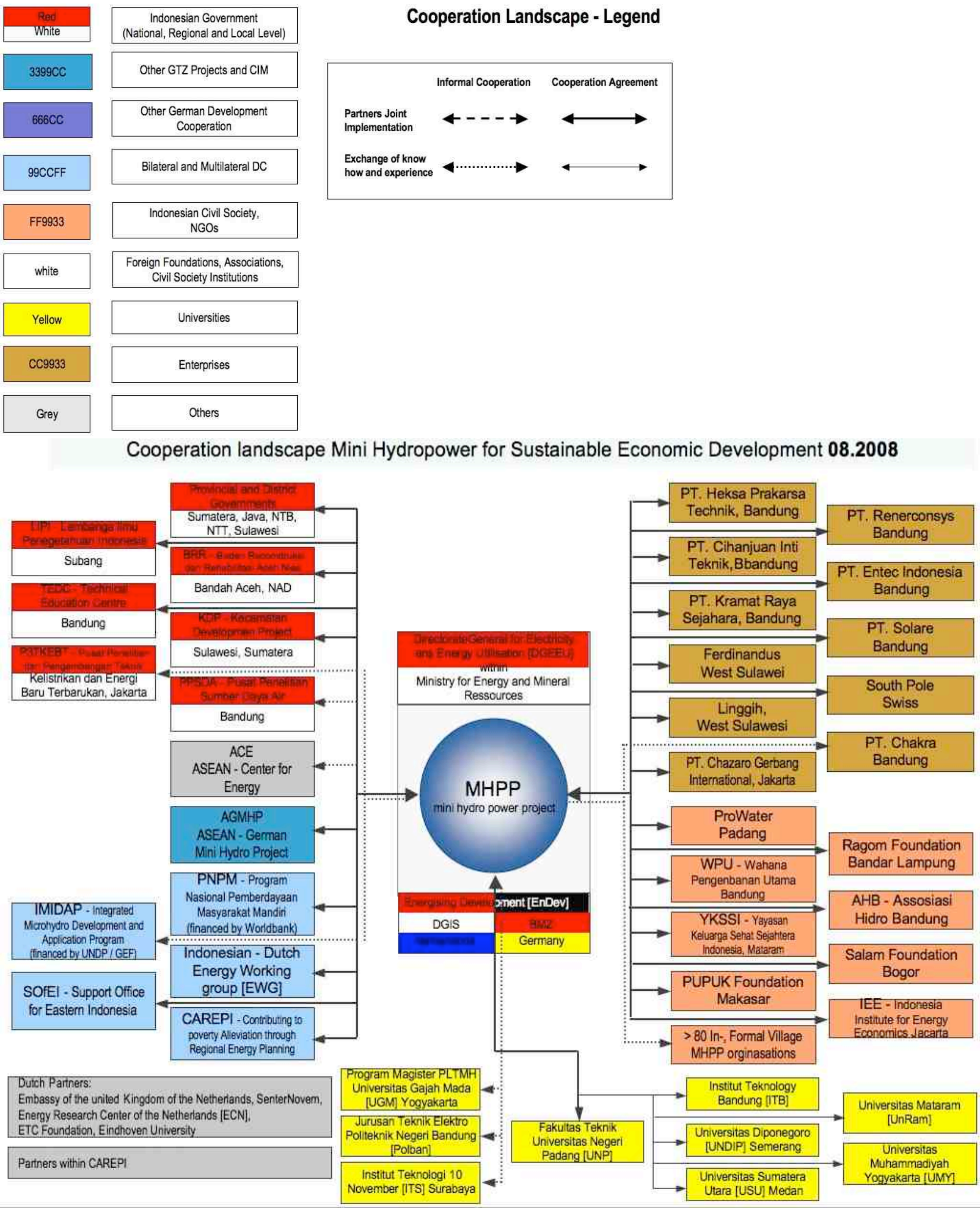
4.3.1 MHPP partners and producers regarding Family Hydro

MHPP FH staff

Gerhard Fischer
Yudistira Christika
Ardi Nugraha
Komarudin

PT entec Indonesia
Jl. Cisatu I 193, Bandung 40142,
Indonesia
Phone: +62 22 203 21 28
Email: office@mhpp.org

MHPP Structure



4.3.2 MHP producers

PT Cihanjuang Inti Teknik (CIT)
Eddy Permadi
Jl. Cihanjuang 204, Cimahi 40513, Indonesia
Phone/Fax: +62 22 664 08 14
Email: hanjuang204@yahoo.com

PT Heksa Prakarsa Teknik/Heksa Hydro
Ir. Kusetiadi Raharjo
Cimindi Raya Blok AK-4, Bandung 40514, Indonesia
Phone/Fax: +62 22 661 30 88
Email: kusraharjo@gmail.com

PT Kramatraya Sejahtera
Jl. Cimindi Raya, Cimahi 40513, Indonesia
Phone: +62 22 665 27 79
Fax: +62 22 665 72 57

4.3.3 Electric load controller

M. Aji – Producer
Komp. Cimindi Raya AL-3 Cimahi, Bandung 40514, Indonesia
Phone: +62 22 6613119, 70077343
Fax: +62 22 6613119
Email: aji.subekti@renerconsys.com

Matthias Wiget – Expert
entec AG
St. Leonhardstr. 59, 9000 St. Gallen, Switzerland
Phone: +41 71 228 10 20
Fax: +41 71 228 10 30
Email: matthias.wiget@entec.ch

4.3.4 Implementing agencies

Hydro Asosiasi Bandung

PT WPU
Faisal Rahadian
Jl. Sabang 25, Bandung, Indonesia
Phone: +62 22 424 03 10
Fax: +62 22 426 14 77
Email: hydro-bdg@yahoo.com

4.3.5 Sulawesi

Pak Ibrahim Pakki/SoFei – Implementer
Jl. Dr. Soetomo 26, Makasar 90113, Indonesia
Phone: +62 411 365 03 20
Fax: +62 411 365 03 23

Pak Linggi - Producer and implementer
Local Producer in central Sulawesi

With experience in MHP installation
Phone: +62 81 524 22 01 55

One-time contacts

Pak Ferdi - Producer and implementer
Local Producer in central Sulawesi
Phone:

Pak Maswedi - Local DINAS in Mambi
Phone: +62 81 343 71 55 54
Gorontalo:

Harman Nurdin (Oman) +62 81 340 40 90 58 Almut Jl. Tribrata 106 Kel. Lpilo, Kec. Kota Timur Gorontalo 96112 +62 435 82 21 78	a) 1 TC 60 as show case. Not yet sold yet. Probably no interest before end of harvest season ~ Oktober 2007) b) OF 125, Gov. Project. 100 mio. 30 km from Gorontalo: (same like the following? ➔) Prorecayasa/Bangbang (+62 81 22 33 71 09) installed OF in Tola Bolo (27 km west of Gorontalo) • 2 x OF 125 installed (still operating) • 2 x 600 W • 6 HH (10 planned)

Tana Toraja/Luntu bepasan (subdistrict)/**Ranteuma**
MPH Salurembo (River)
Abel: +62 81 342 59 54 44

4.3.6 Sumatra

ProWater - Producer and Implementer
Pak Johny Ivan/Pak Osman
Villa Bukit Indah F-9 Limau Manis, Padang, Indonesia
Pak Osman: 081-374703475
Phone: +62 751 791 50 3
Fax : +62 751 705 14 40

4.3.7 MHP producers internationally

Source: http://www.microhydropower.net/directory/manufacturers.php

	Company's Name	**Country**	**Product**
1	Norris Screen and Man. Inc. Coanda Sales	Canada	Coanda Intakes
2	AAA Hydro Power Consultants	India	Detailed Project Reports
3	ABATEC S.A.	Argentina	MH portable hydro turbine
4	ACREST	Cameroon	Waterwheel
5	Action Africa	United States	Large Canvas Shelters
6	AES HYDRO	Bolivia	Cross flow turbines
7	AIMM Technologies, I	United States	Hydrokinetic Cl
8	Alfredssons Maskinaffar	Sweden	Francis turbines
9	Alps Power Technologies (P) Limited	India	STATIC EXCITOR UNIT
10	Alternative Hydro Solutions Ltd.	Canada	Small
11	APROTEC	Colombia	Hydropower
12	ASIAN PAINTS (INDIA)	India	Apcomin & Asioc
13	Asian Phoenix Resources Ltd	Canada	Low Head PowerPal
14	Azad Engineering Company	India	Hydro turbines
15	Barnetech Industrial Consultants Ltd.	Jamaica	Custom built microhydro

16	Bhawal metal industries	India	Alloy steel pipes, sheets
17	Blue flow	Bulgaria	Free flow turbine
18	BOOM Systems Private Limited	India	Hydro turbines
20	Cambodia Best Energy Saving Team (CamBEST)	Cambodia	
21	Canadian Hydro Components Ltd.	Canada	Kaplan
22	Canyon Industries, Inc.	United States	Pelton turbines
23	CARGO & KRAFT TURBIN SVERIGE AB	Sweden	Kaplan turbines
24	Central Philippine Uni - Affiliated Non	Philippines	Crossflow turbine
25	CETA	Cuba	Axial turbines
26	CINK Hydro-Energy s.r.o.	Czech Republic	Crossflow turbine up to 2
27	CLEAN AIR KENYA	Kenya	Crossflow turbines
28	Dans King Limited	Cote d'Ivoire	
29	Deif A/S	Denmark	GPC
30	Delton Cables Ltd	India	Power cable
31	Dencho Nehuen Co	Argentina	Pico,Micro,Mini Pelton W
32	Denon Technologies Ltd	Canada	IGC
33	Dependable Turbines Ltd.	Canada	Francis
34	Derwent Hydro	United Kingdom	Propeller turbines
35	Energy & Engineering Solutions	India	Micro Hydro
36	Energy Systems & Design	Canada	Stream Engine
37	Engineering Associates	Afghanistan	T-15 crossflow turbine
38	entec ag	Switzerland	Consulting
39	Esdee Electromill Pvt. Ltd.	India	White metal lined bearing
40	Evans Engineering Ltd	United Kingdom	The 'Picopack' Range
41	flowmore pvt. ltd.	India	Pump as a turbine
42	GEA SRL	Italy	Small scale power plants
43	Gilbert Gilkes and Gordon Ltd	United Kingdom	Turgo Impulse Turbines
44	GUGLER Water Turbines GmbH	Austria	Kaplan,Francis,Pelton
45	Hartvigsen-Hydro	United States	Orange spoon turgo runner
46	Heidra Ltd	United Kingdom	Optiflow T17 Turbine
47	HS Dynamic Energy Co.,Ltd.	PR China	Kaplan turbine, Micro hyd
48	Hydrogeneration Ltd	United Kingdom	Polymer Turbine
49	Hydrolink	Czech Republic	Kaplan turbines
50	Hydropower Turbine Systems, INC.	United States	Ossberger turbines
51	HYDROSCREEN	United States	Plate wedgewire screens
52	HydroWatt GmbH	Germany	Waterwheels
53	Hyorim Ind. Inc.	Republic of Korea	Intake facilities
54	Importadora TÃ©cnica Ltda.	Chile	
55	INGEHYDRO	Spain	Small scale hydropower
56	IP&L- International Power & Light	United States	SeaStar Floating Platform
57	Jakson Engineers Ltd	India	Generator Control Panels
58	Jalarka Harvesters Private Limited	India	High Efficiency PAT
59	Jalshakti Engineering Pvt Ltd	India	
60	JLA & Co	Belgium	Hydro-electric equipments
61	Kasmer Hydristor Corp	United States	Bicycle transmission
62	Kenya Highlands Agencies Ltd.	Kenya	
63	Krishna Grill & Engineering Works (Pvt.)	Nepal	Pico & Micro hdyro equipe
64	KV ELECTRIC, INC.	United States	
65	KWK -Kleinstwasserkraft Klopp -	Germany	PUR casted Pelton-Wheels
66	Lanka Power Promoters (PVT) Ltd	Sri Lanka	Micro hydro
67	Lignum-Vitae.Com	United States	
68	M/S Radha Structure & Eng. Works (P.)	Nepal	Crossflow Turbine
69	MAX-tec Wasserkraft AG	Germany	

70	MPCL	United Kingdom	Archimedean Screw Generat
71	Multi Service Link Nepal Pvt. Ltd	Nepal	
72	Nautilus Water Turbine	United States	Nautilus Turbine
73	Nepal Yantrashala Energy	Nepal	Turbine
74	Nileshwari Enterprises	India	Energy Meter / Gas Meter
75	ORENGINE INTERNATIONAL	Ecuador	Hydro Energy
76	Orengine International	Italy	Hydro Energy Turbines
77	Outsea Nigeria Limited	Nigeria	
78	Pentaflo Hydro Engineers	India	Turbines for MIcrohydro
79	Petco Renergy.Inc.	Philippines	
80	Phobus tech. Engineering inc. S.a. de c.	Mexico	100W max. power
81	Planetary Power	Australia	Walsh River Micro-hydro
82	Platypus power	Australia	AC turbines, PP series
83	Pompes RITZ France	France	
84	Powerbase Automation Systems Inc	Canada	TCM-30
85	ProViento S.A.	Ecuador	Submergable 500W
86	Quasar enterprises	Canada	
87	RACC Clean Energy	Ecuador	Desarrollo de proyectos
88	Rainbow Power Company Ltd	Australia	Rainbow Micro Hydro Geno
89	Raven Technology	United States	The Blackbird
90	REDCO (Sri Lanka)	Sri Lanka	Turbines
91	Redco Limited	Sri Lanka	Turbines
92	Regency Power Group	India	Power Generation
93	Remote HydroLight	Afghanistan	Crossflow turbine
94	Retrace Electronics	India	Electronic Load Controller
95	RS Hydro	United Kingdom	Open Channel Flow Meters
96	S.N.&CO.	India	Penstock Pipe
97	Sahyadri Energy Systems Private Limited	India	Standard Pelton units
98	Shanghai Witmake Industry	PR China	Hydro turbine
99	solener	Spain	Aerogeneradores
100	Soluciones de Agua y Energia	Colombia	Pico Pelton runners
101	SS control system pvt ltd	India	MCC/PCC Panel/LINE control
102	Standard Electronic Instruments Corpn,	India	ELC systems
103	Steel Industrials Kerala Ltd	India	Turbine
104	Techno Trade	India	
106	Thompson Locomotive and Machine Works	United States	
107	TPSC (INDIA) Pvt. Ltd.	India	Hydro e-Kids
108	Trident Industries	India	Bearings & Bushes
109	TRIFLO ENGINEERS	India	
110	Tyco Tamar	Australia	Turbines
111	U.S. Transformer Inc.	United States	
112	UEK Corporation	United States	10ft diameter
113	Universal Electric Power Corp	United States	Farm or Estate hydropower
114	Universal Instruments manufacturing Co.	India	Battery charger
116	Valley Hydro	United Kingdom	Valley 100
117	VARSPEED Hydro Ltd.	Romania	ELC w. fixed 50Hz output
118	Village Renewable Energy Systems Priv.	India	Pelton Turbines
119	Vinci Aqua Systems (P) Ltd	India	Micro Hydro Turbines
120	Vortex Hydro Systems	South Africa	Cross flow turbines
121	Vortex Hydro Systems	South Africa	Cross flow turbines
122	Wasserkraft Volk AG	Germany	Hydro-turbine equipment
123	Water Recycle Group Australia	Australia	Recycle, PowerPal
124	Watermotor	Bolivia	Watermotor model 90

125	Waterwheel Factory	United States	Custom Waterwheels
126	Wild Water Power!	United States	Build it yourself video
127	Windsor Machinery	United States	Cross Flow turbines
128	Windstream Power Systems	United States	Pelton Turbines
129	Windstream Water Turbines Inc.	United Kingdom	Wind turbines
130	Worthington Products, Inc.	United States	TUFFBOOM
131	YTEK CONTROLS	India	Electronic Load Controller