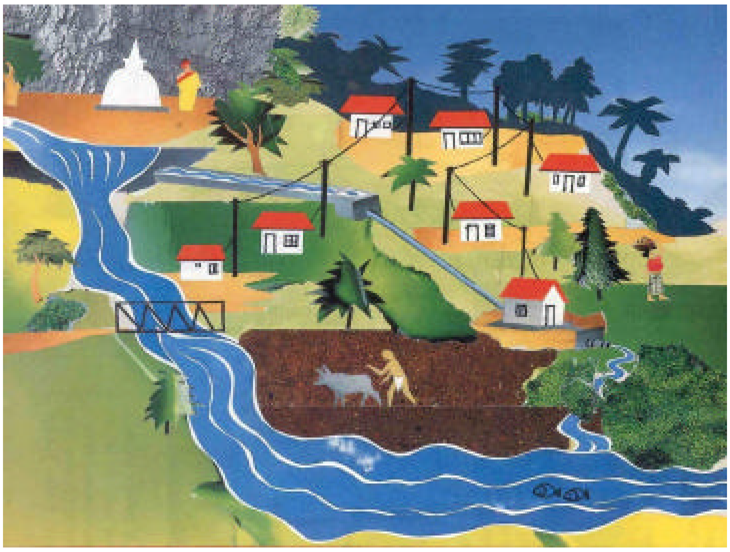
Report of the South Asia Regional Workshop on Developing Standards for Micro- Hydro Sector



Held on
6-8 September 2004

At the
Berjaya Mount Royal Beach Hotel, Mount Lavinia,
Colombo, Sri Lanka

Complied by
Energy Forum, Sri Lanka

(This workshop report was complied with the financial assistance of Winrock International provided under the SARI- E Small Grants Program.)

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Report of the South Asia Regional Workshop on Developing Standards for Micro- Hydro Sector

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1. Introduction

The scope of the workshop was to focus on Rationale and Establishment of Quality Programs for micro-hydro power systems in the SARI countries, and to bring together stakeholders from government, NGOs, industry, Finance, Donor/Aid agencies, user groups, and appropriate Subject Matter Experts. The workshop reviewed existing international standards and best practices for establishment of a Quality Programs and establishment of a framework for developing regional standards. A consensus-based approach was be utilized and discussions were focused on design, implementation, business practices, training infrastructure, and training quality standards. Examples of existing quality standard programs included Workforce Development Standards in India, Sri Lanka, and Nepal, with summaries of how the framework is implemented through stakeholders, standards, and the existing vocational training infrastructure; and quality standards for hardware design and manufacture. The workshop engaged participants in dialogue on the development and implementation of consensus quality competency standards and hardware quality standards; the establishment of appropriate technical committees; engaging the donor and finance community to validate the importance of accreditation and certification as risk assessment tools; engaging the existing national vocational training infrastructure in the country to ensure that the renewable energy training meets the requirements of the existing framework; and engaging industry to ensure that quality manufacturing programs are defined in such a way so as to benefit the industry and minimize the costs.

Overall objective of the workshop was to establishing a framework for developing standards and quality assurance program in the micro hydro sector in South Asia.

Expected Outcomes were to identify priority areas in the micro hydro sector for developing regional standards, a come to a consensus to form working committees to pursue regional, harmonized standards, to identify country representatives and technical experts to serve on the working committees at national & regional level and to develop a regional strategy for standards harmonization and participating in a standards secretariat

It was also expected to compare National & International Standards develop/design quality standards for MH sector that is appropriate for the national context without compromising minimum safety standards.

2. Micro-hydro Quality Standards: Technology and Workforce

Presentation made by Ms. Wendy Parker, Senior Policy Coordinator, Institute for Sustainable Power, Inc, USA

What are Quality Standards?

Performance metrics setting the bar for:

- Hardware: How hardware should perform under given conditions?
- Practitioners (PEOPLE): What people should know? What people should be able to do?
- Training (“Software” Standards): Training content; Practical exercises, examinations
- Management Systems

According to ISO: Documents established by consensus and should; be approved by a recognized body; Provide rules or guidelines for activities or their results; be designed for repeated or regular use; and be aimed at achieving predictable quality

Components of a Quality Renewable Energy System
Four Pieces of the Whole Donut: Training Standards; Hardware Standards; Practitioner Standards; Management Standards. This leads to Industry Success.

Why do Quality Standards Matter? Quality Standards provide for quality hardware & quality practitioner performance: leads to high quality WORK outcomes and supports industry GROWTH

Quality Standards ------> Quality Work Outcomes --------> Growth of the Industry
This facilitate Access to Financing, Insurance, and Markets; Mitigate Liability & Risk; Encourage Workforce Growth; Allow Workforce Portability; Reduce cost and development time through stakeholder coordination; Provide Professional Credibility and Recognition; and Promote Safety & Quality Workmanship.

Effect of Quality Standards on Workforce Development

- Quality standards ensure Customer Satisfaction
- Customer Satisfaction leads to development of the Industry: More jobs, Sustainable jobs and Local jobs

How is Quality Standards Applied?

- Hardware: Accreditation of factories, test labs; Certification of the hardware itself
- Trainers and Training: Accreditation of training programs; Certification of instructors / trainers
- Practitioners: Certification for installers, designers, maintenance technicians, inspectors

Example Programs

- Morocco: Support of PV SHS
  - Hardware Quality via PVGAP/IECQ Certification
  - Workforce Quality via ISP-Accredited Training Program
- China: Support of PV SHS and Hybrid Power Systems
  - Hardware Quality via World Bank Procurement Spec (PVGAP)
  - Workforce Training via ISP Accredited Program, Trained Auditors and Certified Master Trainers
  - Additional Standards in place for Village Hybrids
- Sri Lanka: Support of PV SHS
  - Hardware Quality via World Bank Procurement Spec (PVGAP)
  - Workforce Training via ISP Certified Master Training

ISP Accredited Training Programs and Certified Instructors: Verify the quality and content of renewable energy practitioner training; Installers, designers, maintenance technicians, etc. have the skills & knowledge they need to correctly perform their jobs.

Training & Practitioner Standards: Components

- Task Analysis - Technical Committees Develop Task Analyses
- Program Requirements
- Experience Requirements - ISP Coordinates & Maintains These Pieces
- Recognition Process

What is a Task Analysis?

- Specific to: Technologies- Micro Hydro; Solar Electric; Wind
  Job Titles- Installer; System Designer; Inspector

Steps in Developing Standards

1. Engage Subject Matter Experts
2. Engage Stakeholders

3. Establish Technical Committees
4. Draft Standards
5. Subject Drafts to Review and Comment
6. Formally Adopt & Publish of Standards
7. Maintain and Update

Summary

- Quality Standards for Training and Practitioners depend on a Task Analysis
- ISP Coordinates International Standards
- ISP Recognizes Training & Trainer Quality

3. Micro-hydro market, technology, industry, and training Opportunities in Sri Lanka

Presentation made by Mr. Jayantha Gunesekera, ITDG (SA), Sri Lanka

Status of rural electrification in Sri Lanka: 60% is connected to the grid; only about 80% of households in the country can be finally connected to the main grid; even to achieve this level of electrification it will take about 10 years; and important to note that the remaining 20% need to be electrified only through off grid systems.

Micro hydro - community based rural electrification systems are rapidly filling the vacuum. Viability was first demonstrated in Sri Lanka by ITDG in 1991. Since then reached 255 micro hydro units by the end of 2003. Currently at least 225 schemes are in operation.

Key elements of the MH rural electrification model: Technology; Credit; Policy frame work; Community participation; and enabling environment.

Community participation: Involve from the inception: identification of resources, assessing feasibility & designing, and construction; Communities Invest: labour, material, and cash; 100% managed by village communities (Electrical Consumer Societies): operation & maintenance, management and regulations

Micro Hydro Manufacturers & Suppliers; the technology carriers to the village: Around 20 in active business. Their skills and educational profiles - 10 skills gained through experience, 5 national level certificate courses and 5 Engineers (BSc). Majority of the manufacturers are ITDG trainees.

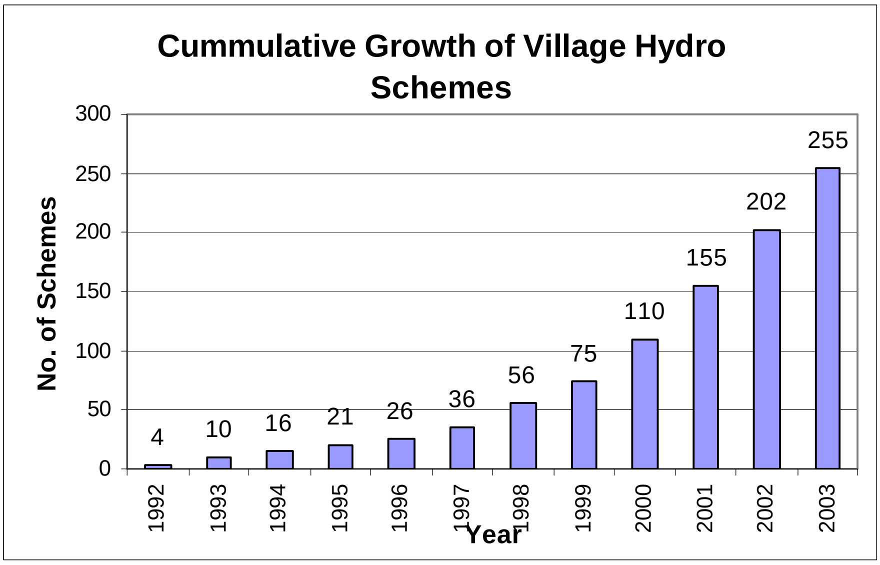
Capacities of the manufacturers

Name	No of Projects	Capacity
Udayaratne	90	500 W – 25 kW
Udaya Hettigoda	45	120 W – 18 kW
Nihal	40	200 W – 25 kW
Shirley	20	1 kW – 200 kW
Kapila	11	250 W – 50 kW
Tony	10	3 kW – 24 kW
Lionel	8	100 W – 7.5 kW

Training avenues-
ITDG is leading since 1990 and conducted continuous on the job training for manufacturers. This includes 6 international programmes on MH System designing (15 – 25 Engineers in each programme);

3 Electronic controllers designing programmes (30 persons each - Engineers and technicians); 2 Turbine designing training programmes (10 engineers each); Conducting feasibility studies training for developers (programme by ITDG 15 participants, 3 programmes by SLBDC 50 participants); Operation, maintenance and management (Carried out by ITDG in pilot sites earlier; FECS carry out now at district level); A comprehensive training programme for manufacturers planed for October in Nepal.

Quality of equipment, services and after sales services not up to the original standards



Market- MH potential study by ITDG under ESD project in 10 districts, revealed - 1000 sites; 41 MW (1- 50 kW range); only 75% utilised. After Sales services for 1000 units is a task.

4. Micro-hydro market, technology, industry, and training Opportunities in India

Presentation made by Mr. K. J. Dinesh, M/s Tide Technocrats Pvt. Ltd., India

Evolution of Indian Electricity Sector
Pre reforms (until 1990s): Generation, Transmission & Distribution owned by state run utilities; Private sector only permitted captive generation; Private generation & supply only in special cases.
Post reforms: Private sector generation encouraged; MNES laid down guidelines for preferential tariffs to RE projects; Electricity Act 2003 promotes concepts of license free distributed generation especially for rural areas and open access.

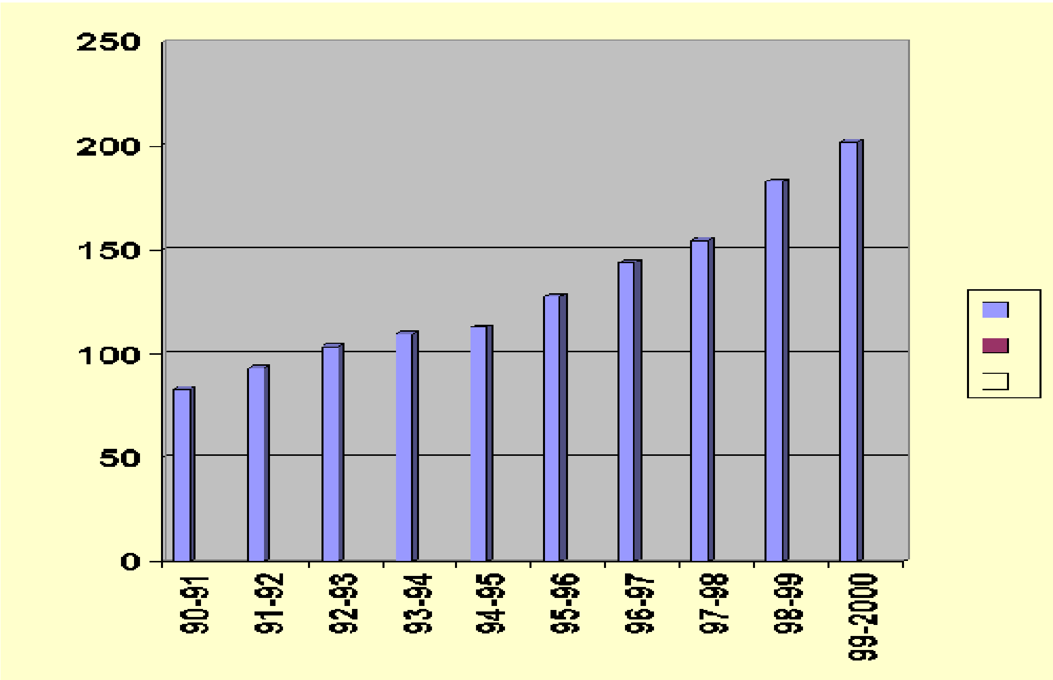
Evolution of small hydro in India
Pre-reforms
- Small hydro projects implemented mainly by state owned utilities
- General belief – BIGGER THE BETTER & MICRO-HYDROS NOT VIABLE
- Some micro-hydros also set up as technology demonstrators and to meet social obligation.
- A few micro-hydros set up in tea plantations for captive use under private ownership

Post reforms
- Private sector investing in small hydro and selling power to grid at preferential tariffs / wheeling & banking.
- Keen interest in off-grid micro-hydels for village electrification due to GoI programme to electrify all villages.

Small Hydro development status in India

	Projects	Capacity
Constructed	420	1423 MW
Under construction	187	521 MW
Potential	4096	10,071 MW

Growth of small hydro capacity (of projects < 3 MW)



Markets for Small hydro in India
IPP Market (>1 MW with grid access): About 10,000 MW capacity spread over all states yet to be harnessed.
Captive micro-hydros: 40 projects identified (upgradation / greenfield) in Darjeeling; Potential also exists in Assam in North East India & in Nilgiris in South India
Village electrification (micro-hydros): About 24,000 unelectrified village identified out of which about 8,000 will be with micro-hydros

Main players
Buyers - small hydro: State Electricity Utilities, Private Power generation companies
Buyers - micro hydro: State Nodal Agencies for RE, Village energy enterprises, Plantations
Manufacturers- 10 entities offering only Small Hydro; 2 entities offering Small Hydro + micro Hydro; 12 entities offering only micro hydro; Local technicians / workshops also offer micro-hydro systems
Consultants- AHEC has enlisted 30 consultants; MNES and state nodal agencies have their own lists of consultants; Contractors for turnkey / specific works exist in all states

Technology Status – small hydro
State of the art technology available
Good range of turbines available: Peltons, Turgo-impulse, Francis, Kaplan, Propeller
Capacity exists for manufacture of other components: Alternators, Governors, Controls & switchgear
Range of performance available: Low efficiency (<10%), ungoverned systems to reasonable efficiency (>50%) well engineered systems
Range of turbines available: Peltons, Turgo-impulse, cross flow, pump as turbine, Crude non-standard impellers also offered
Generators: Alternators – with brushes & brushless, Induction generators available

Governing: Electronic Load Controller offered, Technology & its delivery needs to mature
Problem areas: Reliable load governing, Handling run away conditions safely, Synchronising multiple generators, Load management

Industry Preparedness
Decent experience in installing micro-hydros: About 100 projects installed in different parts of India; Technology related problems understood and industry capable of evolving solutions; 3 Indian manufacturers have bid for the first village electrification tender in Arunachal Pradesh. Larger players adopting a wait and watch policy

Accreditation & certification
Quality systems accreditation ISO 9000 etc. are quite common in India. Product certification are carried out by: Alternate Hydro Energy Center (AHEC), IIT Roorkee; Central Power Research Institute (CPRI), Bangalore; Bureau of Indian Standards. Some of the above may have to strengthen their facilities to cater to full range of micro-hydro

Constrainers
Subsidy driven market with emphasis on project implementation and not on long term sustenance: Will there be a sustainable growing market?
Current manufacturers in micro-hydro are motivated by 'passion' and need capital support to: improve technology & standardise; extend their marketing network

Key interventions
Make micro hydro sustainable: Change in mind set, Development of ownership / institutional models, Development of economic models
Strengthen delivery capability: Product improvement & standardisation of existing small manufacturers; Win confidence of large manufacturers
Reduce risk perception for all players

Technical standards to be evolved
Overall performance standards: Efficiency, Reliability, Quality of electricity and Safety and protection
Standards for project design: Civil design, E&M specification, Distribution system design, and Economic modeling

Training Opportunities – Institutional: Development of a mindset towards ensuring 'sustenance' among organisations such as: State Nodal agencies, Panchayat Raj Institutions, and Financial / Managerial intermediaries. Training of project owners in: Technology & project design; Financial modeling; Management and accountability; and Other issues that influence sustainability

Training Opportunities – Individual: Development of a pool of trained manpower capable of: Technical feasibility assessment; Economic modeling & feasibility assessment; Local ownership development (entrepreneur /community/PRI); Overseeing project implementation; Providing technical and management assistance to local entrepreneurs

5. Micro-hydro market, technology, industry, and training Opportunities in Nepal

Presentation made by Mr. Hari Bhakta Gautam, Nepal Micro-Hydro Manufacturers Association, Nepal

The term 'micro-hydro' refers to hydro electric installations with a power output between 2 kW and 300kW. These installations are generally characterized by a low head and a low flow rate. Often, they can be realized at minimal impact on the river's eco-system and at minimal cost. They hence present the ideal solution for energy production in third world countries where capital is scarce and the local economy may depend strongly on an ecological sensible management of the natural resources. The history of waterpower in Nepal begins with the traditional water mills or ghatta used for grinding flour, However, there are a variety of technologies already available or being developed, which come under the mini and micro hydropower category. The improved ghatta i.e. Multi-Purpose Power Unit (MPPU) is an innovation on the traditional ghatta, which uses a metal runner to increase efficiency higher than that of traditional ghatta.

Nepal, one of the richest countries in terms of water resources potential, has not been able to utilize its potential for power generation. Out of 83000 mw theoretical potential, only about 500 MW power has been generated.

Classification of Hydro-Power in Nepal

- Large : Above 50MW
- Medium : 10-50MW
- Small : Above 1000kW- less than 10MW
- Mini : 101-1000kW
- Micro : Up to 100kW
- Pico : Up to 3kW (combined unit of induction generator and small pelton runner)

Market f Micro Hydro in Nepal

The market of micro hydro in Nepal is extensively high because only 25% of the total population has access to electricity and the 10th plan has targeted to generate 10 MW of electricity from micro hydro in the next 5 year. Nepal is known as a country with huge potential of hydropower. Unfortunately, only 20 percent of the population has access to the national electrical grid and a large number of Nepalese populations are yet to enjoy the benefits of electricity. In Nepal a lot of Small Falls, Rivers, and Streams can be used to produce Renewable Energy Micro Hydro Power. More than 60% people live in remote areas where large projects cannot be launched due to the high cost of distribution and production. Nepal being a country of rural and isolated committees, the suitability of micro-hydro systems is distinctly visible. NEA has been responsible for on-grid electrification where as AEPC has been responsible for off-grid electrification in Nepal. In addition to NEA, Small Micro hydro Projects and Independent Power Producers (IPPs) are also very much active in the hydro power sector.

Micro Hydro Technology

In Nepal, about 76% of the turbines are cross flow followed by 20% MPPU and 13% pelton. Initial stage hydraulic mechanical governor used to control mechanical power. Later IGC (induction generator controller) and ELC (electronic load controller) used for electrical power control. Now we are using hydraulic flow regulating valve drive with electric dc current for pelton turbine and cross flow turbine which is used for water flow and power control. We have planned to use t15 cross flow turbine, design by ENTEC engineering consultant Switzerland, for generating high efficient mechanical power. Pelton turbine (Capacity - 18 kW) is assembled in workshop.

Industries

More than 15 Industries are engaged in the field of Micro Hydro. They Manufacture, Design, Install the Project. More than 30 consultancy firm are established. Their function is to: Survey the Location, Feasibility Study, Design the Project, Assure Quality Control and Monitor.

Major Industries in Micro- hydro In Nepal

- Butwal: Appropriate engineering, Gautam engineering, Nepal Machine and Steel Structures, Nepal hydro electrics and Thapa Engineering.
- Katmandu: Balaju yantra shala, Himalayan Power Producers, Katmandu Metal Industry, Nepal Yantra Shala Energy, Power Tech Nepal, Radha Structures and Engineering Works and Krishna Grill and Engineering Works at Biratnagar.

Nepal Micro-hydro Power Development Association (NMHDA)

NMHDA was established in 1992 for the development of technology and research needed for micro hydro schemes. It is the central association of manufacturers, installers and consultants. The aim of NMHDA is to have an exchange of ideas about the technology.

Training Opportunities

Different NGO's and INGO's are underpinning on the job training for fulfilling required skilled manpower. Some manufacturing companies also provide training. But there are no specific institutions where trainee could get complete knowledge about survey, design, installation, and manufacturing components. NMHDA conducts training for operators, managers and surveyors in association with ESAP, REDP and other donors including government. NMHDA also conducted some programmes including the exhibition of micro hydro, organized lecture programmes to the engineering students of Katmandu University on MHP development. We are commencing new institute (affiliated by CTEVT) for producing skilled manpower. It is expected to qualify skill manpower by establishing appropriate institution. We are very much interested in establishing South Asian collaboration for micro-hydro power development in the region.

6. Problem Analysis in the Micro Hydro Sector in relation to Hardware Standards, Practitioners Standards and Training Standards and identify areas for developing regional standards

Findings of the Group Discussions & Plenary

Problems relating to Micro-hydro Hard Ware

Lack of specifications for all IGCs, turbines, generators is an issue in the sector. There are issues of material quality. In most instances out put parameters are not specified. Differential standards are also visible. Hence Standardized specification is a requirement. In certain areas there are standards on paper. However Generators are not conformed to existing Standards. There are no certified bodies to check the quality of locally manufactured items. Potential Accreditation Organizations are Industry associations, Government standards departments, and National Accreditation body. It is also necessary explore the affordability of the consumers in the presence of mechanisms relating to standards.

Needs assessment relating to Micro-hydro Practitioners

There are Major problems relating to capabilities of village-hydro developers and equipment suppliers. It is necessary to develop guidelines for different practitioners. Guidelines can be adapted from the solar PV systems. There should an Economic analysis while developing the system design. Currently there is no flexibility for small system designing. There is only one standardized design for small systems. It is necessary to develop specifications in linear years for catchments area for the micro-hydro schemes. There is a centrally controlled verification agency (APEC) for micro-hydro technology in Nepal.

Training requirements

Training is an essential component in following sectors: Training for manufacturers, Training for project preparation consultants-Design Engineers, End users (Electricity Consumer Societies) and Verification engineers. Vocational training and Social Mobilization modules can be utilize for this purpose.

7. Existing Micro-hydro Standards and Quality Programs in the Region

Presentation made by Ms. Wendy Parker, Institute for Sustainable Power, Inc, USA

What are the Components of a Quality System for Renewable Energy / Distributed Generation?
Hardware Standards & Software: Training Standards; Practitioner Standards; Quality Management Standards

Which Components Already Exist?
Hardware: ISO; IEC - PVGAP; Various national programs, including Sri Lanka
Trainers and Training: ISPQ Standard; Various national applications
Certification of Practitioners: In U.S.: NABCEP
Management Systems: ISO Certification; ISPQ Accredit / Cert requires Quality Management Systems; Various national programs, including Sri Lanka

IEC

IEC 61364 TR3 Ed. 1.0 b (1999)
Nomenclature for hydroelectric powerplant machinery
IEC 61364 Corr.1 Ed. 1.0 (2000)
Nomenclature for hydroelectric powerplant machinery
IEC 61116 Ed. 1.0 b (1992)
Electromechanical equipment guide for small hydroelectric installations
IEC/PAS 62111 Ed. 1.0 en:1999
Specifications for the use of renewable energies in rural decentralised electrification

ISO

ISO 4362:1999: *Hydrometric determinations -- Flow measurement in open channels using structures -- Trapezoidal broad-crested weirs*
ISO 4375:2000: *Hydrometric determinations -- Cableway systems for stream gauging*
ISO 4377:2002: *Hydrometric determinations - Flow measurement in open channels using structures - Flat-V weirs*
ISO 14139:2000: *Hydrometric determinations -- Flow measurements in open channels using structures -- Compound gauging structures*
ISO 772:1996: *Hydrometric determinations -- Vocabulary and symbols*
ISO 772:1996/Amd 1:2002: *AMDT 1 - Hydrometric determinations - Vocabulary and symbols*
ISO 8368:1999: *Hydrometric determinations -- Flow measurements in open channels using structures -- Guidelines for selection of structure*

American Society for Testing Materials
ASTM D6439-99: *Standard Guide for Cleaning, Flushing, and Purification of Steam, Gas, and Hydroelectric Turbine Lubrication Systems*
Various National Electrical Codes
Sri Lanka and other Asian countries have various codes and standards
APEC draft Micro Hydro Task Analysis
Intermediate Technology Development Group (itdg.org) in Sri Lanka has run training

- Curriculum?
- Adam Harvey
- Rohitha Ananda

Sri Lanka has a Code of Practice for Electrical Installations

Other Draft Task Analyses

- Hybrid Wind-PV (China)
- Biogas (Australia)

These describe what an installer / designer / maintenance technician needs to know and be able to DO to perform correctly.

Practitioner Certification

- The North American Board of Certified Energy Practitioners (NABCEP)
- PV Installers
  - Have experience installing systems
  - Have training
  - Pass a written examination
- End result: Practitioners are Certified

Quality Management Systems

- Quality Management ensures that processes and procedures:
  - Yield the expected outcomes
  - Yield quality outcomes
  - Undergo continual assessment and improvement
  - Documentation is appropriate
  - Staff is properly trained

Survey of Asia-Region Projects

- World Bank Energy Services Delivery Program
- World Bank QUAP-PV Training Project
- SARI/Energy contract under the USAID and CORE International
- Solar Finance Consortium through USAID

World Bank Energy Services Delivery Program (1997 – 2002)

– Fostering the implementation of grid-connected mini-hydro power by the private sector
– Partners: Government of Sri Lanka, Ceylon Electricity Board, Commercial banks, Micro-financing institutions
– ITDG did training in conjunction

World Bank QUAP-PV

Training on establishing Quality Systems for training in renewables
Training in Jaipur, India, October 1999
Training in Sri Lanka, February 2000: train the trainers; PV focus

SARI/Energy

To establish sustainable training of bankers in the network of rural regional banks in India: Over 3 years (from 2000-2002);
Developed curriculum and trained the instructors. Then piloted the program through syndicate banks and trained several thousand bankers in how to evaluate loan applications for solar systems.

Summary

Many hardware standards relevant to micro hydro already exist. Fewer "software" standards exist. A draft Micro Hydro installer Task Analysis has been developed through an APEC contract.

Action

- Build on the existing APEC draft Micro Hydro Task Analysis
- Refer to other relevant Task Analyses
- Refer to relevant Hardware standards
- Refer to other relevant "software" standards

8. Standards and Quality Programs in Sri Lanka

Presentation made by Jayantha Nagendran, RERED Project, Sri Lanka

A 'micro hydro' is an isolated water-driven power supply that serves a cluster of rural consumers who are members of an Electricity Consumer Society (ECS) that owns and operates the scheme. The ECS is responsible for operations, maintenance and management, including tariff determination. A typical micro hydro (village hydro) has a capacity of 10 kW and serves about 40 households within a 2 km radius with 230V, 50Hz electricity.

ITDG Sri Lanka pioneered the promotion of 'village hydros' from the early 1980s: Basic manufacturing technology, Model based on community participation, Funded through philanthropic initiatives

Energy Services Delivery (ESD) Project: 1997-2002: Technical specifications introduced, Capacity building for suppliers and developers, Business model for ECS, Commercial financing through banks. Added 350 kW through 35 technically certified schemes financed with commercial loans and grant, serving 1,732 homes

Renewable Energy for Rural Economic Development (RERED) Project: 2002 – 2007: Continuation of ESD initiatives, Capacity building also for consumer societies, Registration of suppliers and developers leading to accreditation later, Testing of small turbines at NERD Centre, National policy framework for renewable resource based electricity generation. RERED Project, up to June 2004: has added 329 kW through 33 certified schemes serving 1,557 homes and several more under construction.

Quality Programs

Technical Standards
ESD Project introduced the 'Village Hydro Specifications - Sri Lanka'
Scope: Introduction, General requirements, Civil works, Mechanical components, Electrical components, Battery distribution, Line distribution. Download from: www.energyservices.lk

Village Hydro Specifications target the Developer who is responsible for project preparation. Specifications strike a balance between quality and affordability, and mitigate investment risk. Compliance verified by ESD/RERED-retained Chartered Engineers at: Scheme design stage prior to loan approval, and Commissioning stage prior to release of grant

Component Design & Manufacturing
Peltons made to specs that are about 2 decades old; very little knowledge on low head turbines. IGC design training was provided under ESD. Many are self taught small entrepreneurs. No formal quality programs in place.
RERED initiatives: Registration (not accreditation) of suppliers/subcontractors; Warranty and minimum service standards; Name plates and block diagrams; Consumer protection scheme

Project Preparation:
30 developers trained under ESD; Developers often outsource technical aspects; No formal training or competency certification of Developers, who are the weakest link in the industry.
RERED initiatives: Registration (not accreditation) of developers; Service standards controlled through staggered payment for project preparation work based on compliance with tech specs and bank loan approval and disbursement; Consumer protection scheme

Operation & Maintenance
Developer sets up and trains the ECS on operation and maintenance, safety and general management. Post-installation compliance with standards (e.g. maintenance of distribution lines) largely unsupervised. No formal training or competency certification of ECS.

RERED initiatives: Capacity building for ECSs; Documentation (plant log book, minutes of ECS meetings, financial records etc) verified before grant release

Testing and Certification
National Engineering Research & Development (NERD) Centre is setting up a micro hydro turbine testing facility (up to 15 kW). No facilities for testing or certification of other components. RERED-retained Chartered Engineers verify the design and installation of micro hydro schemes.

Recommendations
Required
Component Design: Mechanism for technology transfer to achieve efficient product performance, durability and safety while being price competitive.
Manufacturing: Quality standards for manufacturing processes, raw material sourcing etc, leading to accreditation of Manufacturers/Suppliers.
Project preparation: Formal training programs for Developers on theory and practice; verify competency and accredit them.
Operation & Maintenance: Periodically verify compliance with standards and general competency of ECSs after project commissioning.
Testing and R&D: Develop the capabilities of organisations such as NERD Centre and Design Centres at the University of Peradeniya and Moratuwa.
VH Specs: Periodically review and harmonize.
Infrastructure: Institutionalize quality programs, identifying the respective agencies and their roles.

9. Standards and Quality Programs in India

Presentation made by Mr. Arun Kumar, Alternate Hydro Energy Centre, IIT Roorkee

Standardised equipment, uniform and works construction practices bring significant economy, reliability and speed in micro hydropower development considered a viable open for rural development through electrification. Standardisation leads to uniformity in design, manufacturer, and construction as well as to reduction in inventory. It also leads to safe and better operation and maintenance. In India, with the active participation and uniform adoption by State Electricity Boards/Power Corporations, the standardized equipment and construction practices for transmission and distribution works in rural areas are followed. Rural Electrification Corporation Ltd. (REC) along with Bureau of Indian Standards drew these. However in micro hydropower development, such practice for generating equipment and construction of civil works is not practiced. Some of the standards are available but these do not give specific details for micro hydro.

Remote Village Electrification
In a recent development, Government of India has taken a decision to electrify all villages including those in remote areas. About 100,000 villages out of over 600,000 villages are yet to get electricity. A village is considered remote if the grid cannot be extended in next 10-20 years economically. Use of renewable energy is considered only the viable option for electrifying these villages. Over 8,000 villages out of 25,000 remote villages are expected to get electricity through micro hydropower as source. The scope of the Remote Village Electrification (RVE) Programme and the desirability of taking up a larger number of villages for electrification through mini / micro hydro systems formed the basis of recent deliberation and standardization and quality controlled. The importance of evolving standard packages of light weight, low cost, efficient, compact and robust sets with minimal civil works and optimized distribution system, and short project gestation period are considered to be given due weightage. Considering the remote locations, it was considered that village hydros should be taken up on turnkey basis with extended warranty, spares for five years and provision for annual maintenance cost (AMC).

The ratings of standard packages for small hydropower installation as village hydro projects may be grouped in the following three categories:
Up to 10 kW – basically to serve one village;
Above 10 kW -100 kW – basically to serve one or a small group of villages;
Above 100 kW-1000 kW – basically to serve a cluster of villages from single project

Depending on the regions and locations of the projects, the components such as civil works, transmission and distribution works, transportation and cartage will vary and may be grouped into the following categories: N.E. Region, Sikkim, Uttaranchal, J&K and Himachal Pradesh (Special category States); Notified hilly regions of all other States & Islands; Plain and other regions of all other States

Standard Specifications for Micro Hydro

<u>Electromechanical Works</u>

	Description	**Category (Installed Capacity in kW)**		
		Category A (Up to 10 kW)	**Category B (Above10 kW and up to 100 kW)**	**Category C (Above 100kW and up to 1000 kW)**
Turbine	**Types**	? Cross Flow ? Pump as turbine ? Pelton ? Turgo ? Axial Flow Turbine ? Any other turbine meeting the technical requirement	? Cross Flow ? Pelton ? Turgo Impulse ? Axial Flow Turbine ? Francis ? Any other turbine meeting the technical requirement	Cross Flow ? Pelton ? Turgo Impulse ? Axial Flow Turbine ? Francis ? Any other turbine meeting the technical requirement
	Rated Output at rated head (at Generator output)	Up to 10 kW	(Above 10kW and upto 100 kW) as specified	(Above 100kW and upto 1000 kW) as specified
Turbine	Minimum required Weighted Average Efficiency of the turbine (?T Av) 0.50 x $?T_{100}$+0.50 $?T_{50}$	40%	50%	60%
	Bid evaluation – equalization for shortfall in overall weighted average efficiency	Nil	Each 3% by which rated average efficiency (computed) is lower than the highest weighted average efficiency	Each 5% by which rated average efficiency (computed) is lower than the highest weighted average efficiency
Generator	**Types**	Synchronous / Induction - Single Phase	Synchronous/ Induction/ 3 Phase	Synchronous 3 Phase
	Terminal Voltage	230 V, 1 -phase	415 V 3 phase	415 V or 3.3 kV, 3 phase
	Make and	Standard / Special generators designed to withstand against		

	Runaway withstand	continuous runaway condition.		
	Insulation and Temperature Rise	Class F insulation and Class B Temperature rise		
Control and Switchgear and Metering	**Controller (Preferable/Micro processor based)**	(ELC) Electronics load controller or IGC Induction Generation Controller	(ELC) Electronic Load Controller or Flow Control Governor	Flow Control Governors
	Ballast Load of Electronic Load Controller	Air heater (by cooking ring)	Water Heater	Not applicable
	Inertia and Flywheel	Adequate flywheel should be provided for isolated operation. Confirm suitability.		
	Switchgear / Earth Fault Protection	MCB/MCCB for O.C. Protection Provide Earth Leakage Circuit Breaker (ELCB)		
	Metering	As required.		

Civil works

Item	**Category (Installed Capacity in kW)**		
	Category A (Up to 10 kW)	**Category B (Above10 kW and up to 100 kW)**	**Category C (Above 100kW and up to 1000 kW)**
Weir	Temporary	Semi Permanent	Permanent
Forebay Tank & Desilting Tank(DT)	Temporary/Semi Permanent	Permanent	Permanent
Channel	Unlined/lined	Lined	Lined
Penstock	PVC/Steel/LDPE	Steel/PVC/LDPE	Steel/LDPE
Power House Building	Simple building without any permanent equipment lifting facility	Simple with fixed equipment lifting facility	Simple with hand operated traveling crane
Access	As available (track, road)	As available (track, road)	Road

Transmission & Distribution Works

Category (Installed Capacity in kW)		
Category A (up to 10 kW)	**Category B (Above 10 kW and up to 100 kW)**	**Category C (Above 100kW and up to 1000 kW)**
Cable and or two wire overhead lines	Four wires overhead lines for transmission and or Cable for distribution with step down transformers through 11 kV/415 V.	Four wires overhead lines for transmission and or Cable for distribution with step down transformers through 11 kV/415 V.

Standards and Guidelines

Some international and national standards and guidelines are available in this sector.

- IEC-61116(1992): Electro mechanical Equipment Guide for Small Hydroelectric installations.
- IEC-60545(1976): Guide for commissioning, operation and maintenance of hydraulic turbines.
- IEC-62006: Hydraulic machines – Acceptance tests of small hydroelectric installations (draft).
- ASME PTC (18-2002): Hydraulic Turbines and Pump – Turbine – Performance Test Codes.
- IEEE Std. (1020-1988): Guide for Control of Small Hydroelectric Power Plants.
- IEEE Std. (1982): Requirement for Salient Pole Synchronous Generators and Generators/Motors for Hydraulic Applications.
- REC- Rural Electrification Construction Standards (1993)
- No. 175-Standarisation for Small Hydropower CBIP, New Delhi 1985.
- IS-12800-1991(2003) Part-III: Guidelines for selection of turbine and preliminary dimensions of surface hydro station – small/mini/micro hydropower hours.
- IS-472 – Performance of hydraulic turbines and pump-turbines.
- IS-4722 – Rotating Electrical Machines

No specific Indian Standards and Quality Programmes for Micro Hydropower is available in India.

Testing of Micro Hydro Equipment

Hydraulic efficiency measurement is prerequisite for good performance of hydraulic machinery and product quality improvement. However, since the costs of such measurements are high, operating company often abstain from testing and measurements. For this reason, new ways for cost effective measurements are to be found. Internationally a draft IEC-62006: Hydraulic machines – Acceptance tests of small hydro electric installations is being prepared. Hopefully this will help in achieving standard acceptance and quality control of micro hydro installations including turbines, generators and flow control.

Situation in India

Government of India who subsidies small hydropower (SHP) installations in different ways has made mandatory for all SHP producers for getting conducted performance test and evaluation report of their stations after commissioning their SHP projects for ensuring the projected generation and agreed efficiency of the equipment. Such tests / performance reports are to be conducted / prepared by the AHEC as latest circular of MNES, Govt. of India (2003). AHEC procured all field-testing equipments in India related to performance evaluation along with 3 regional technical institutions, we as the apex organisation.

AHEC was set up in the year 1982 at the IIT Roorkee with the initial support from the MNES, GoIto promote power generation through the development of Small Hydro and other renewable energy sources. The centre is engaged in running M. Tech. programmes, training programmes, R&D, providing consulting services, collection, storage, processing and analysis and dissemination of data, particularly relating to SHP. AHEC has provided technical support to over 20 Central and State level organizations in India for 400 MW SHP capacities. AHEC has recently acquired some necessary field-testing equipment for conducting performance and residual life evaluation of SHP stations. A group comprising faculty and professionals of IIT Roorkee from AHEC and the departments of Elect, Civil and Mechanical Engineering conducts tests on SHP stations, analyse the results and prepare DPR. AHEC is engaged, with the help of the MNES, GoI, has set up a network with other institutions in different regions of India to cover the entire geographical area. It is expected about 40-50 small hydropower stations of different size and variety shall be commissioned every year and tested. The other members in the network are National Institutes of Technology at Bhopal, Tiruchirapally, and Jadavpur University. Often, the techniques and instrumentations employed for performance monitoring and testing of SHP Station is exhaustive, time consuming and highly expensive.

Status of Indian Standards for Selection, Testing and Certification of Shp Equipments
Hydraulic Turbines

- Quality of materials;

- Quality of manufacture (in accordance with modern practice);
- Runaway (speed and behaviour);
- Speed rise and pressure rise;
- Leakage through the discharge regulating apparatus;
- Cavitation (the amount of material lost through cavitation pitting on turbine components can form the basis of a guarantee with a guarantee period of the order of 8,000 h of operation, but not longer than two years);
- Output or discharge;
- Efficiency;
- Temperatures of guide and thrust bearings (which may be part of the generator).

Hydro-Generators

The Small Hydro generators may be synchronous salient pole machines or induction generators. There is no specific Indian standard for salient pole generators and generators/motors for hydraulic applications. The American National Standards Institute (ANSI)/IEEE has however issued specific standard "Requirements for Salient Pole Synchronous Generators and Generators/Motors for Hydraulic Applications", Standards Institute (ANSI)/Institute of Electrical and Electronics Engineers (IEEE), 1982.

The special requirements of the hydro generators as per IEC 61116 are highlighted below:
Standardised or upgraded mass produced machines available off the shelf should be used. The machine should be designed for continuous operation at runaway conditions specially, in the micro range and as induction generators. These machines are generally not available and thus affecting the shp program. Synchronous generators excitation system should be designed for power factor control when in grid-connected mode. This is also not easily available.

Governing Systems

The governor is a key component in a small hydroelectric installation. In case of micro range shp shunt load governors (electronic load controllers) are invariably used to control speed in an isolated system by varying load on a dump load system. Digitally controlled governors are cost effective and are replacing mechanical governors. These have been recommended for use as integrated control and protection equipment for shp in India. No Indian standard is available for governors specification and testing. International and American Standards indicating requirements of Governors and their testing are available.

Conclusions

We can see there is an urgent need of manuals, procedures, and guidelines for standards and quality control in the region. A list of some of the publications, which could be referred for preparing such standards, is given in the reference. Some of them have been referred in preparing the paper.

10. Standards and Quality Programs in Nepal

Presentation made by Mr. Ram Prasad Dhital, Alternative Energy Promotion Centre, Nepal

MHP Development & Its Trend

Micro hydro regarded as the first renewable energy technology to electrify rural places of Nepal [almost 25-30 years back]. From 1962 to Mid-July 2003, about 429 numbers of Micro Hydro electrification schemes installed with total capacity of 7471.8 kW. 942 numbers of Peltric sets have also been installed with total capacity of 1637.8 kW.

Government Plan and Policy

The 10th Plan (2003-08) has targeted to generate 10MW electricity from isolated hydropower schemes

No license required for plants up to 1 MW. Liberty is given to fix the tariff rates. Subsidy Policy in place: Provision for output based subsidy; Subsidy for rehabilitation projects; Provision for transport subsidy; Criteria for subsidy (investment ceiling, end use, O and M cost)

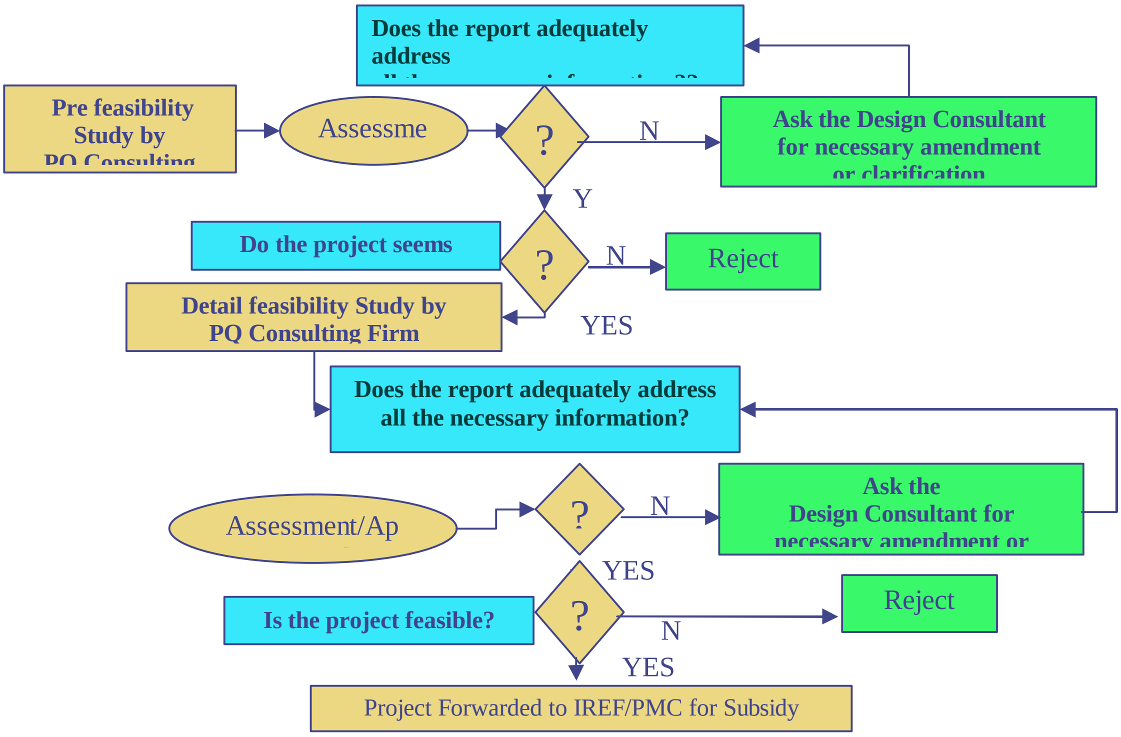
AEPC's Experiences in Quality Aspects: AEPC, the Govt. organization under MoST was established in 1996 & has been strongly supported by Donors. The Overall objective of AEPC is to support the government's objective of improving the living standards of the rural people by supporting AETs. AEPC is executing DANIDA and NORAD supported ESAP (Private and Community based MHPs) and UNDP and WB supported REDP (Community based MH schemes) for MHP development in Nepal. Technical Review Committee (TRC) has been formed in order to maintain one door concept for streamlining the operations for uniformity as well as for coordination among different donor funded MHP projects. The specific objectives of TRC are: To ensure the sustainability of micro-hydro power projects; To coordinate among the projects being facilitated by various programs; To make uniformity on project assessment and appraisal; To prepare uniform basis for subsidy recommendation

Composition of TRC: Energy Officer, AEPC, Coordinator (Govt.); Representative ESAP- Member (Donor); Representative REDP- Member (Donor; Representative ADB/N- Member (Bank); Representative NMHDA- Member (PSO).

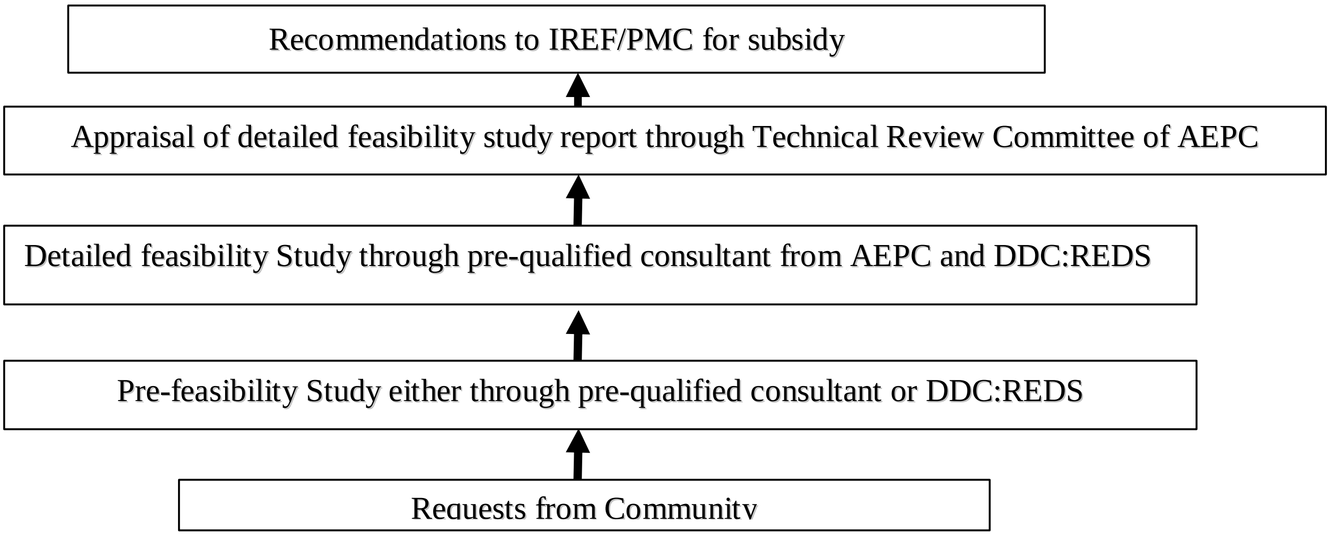
Quality Control / Support Activities includes: Appraisal of the project; Quality inspection during the construction of the project; Power Output Verification and One year guarantee Check.

Project Appraisal involves checking and/or analyzing the project design document using many of the same criteria and analytical tools that were applied during the project preparation stages *but with a bit conservative approach*. According to the overall criteria: Plant should be able to generate the installed capacity at least 11 months a year, reliably and cost effectively and 15 years life, plant income should cover at least operation, maintenance cost & payback of loans + return on equity.

Assessment /Appraisal Flow Chart



Existing Subsidy Delivery Mechanism



Existing Micro-hydro Guidelines

Guidelines: Pre feasibility study Guidelines; Detail feasibility study Guidelines; Tariff Setting Guidelines; Model Biding Document; Social Mobilization Guideline

Pre qualification: Consulting Firms; Manufacturers, Fabricators & Installers; Quality Supervisor, POV inspectors

Technical Standards: Micro Hydro Interim Standards; Pico Hydro Standards

The objectives of technical standards is to improve the quality & safety aspect of electricity services from MH project with the ultimate aim of Standard, Quality in MHP is gradually improving from design to construction, Design & Report standards have generally improved, More experienced consultants and to include Improvement in quality requires constant effort from all concerned stakeholders (.e., developer, consultant, installer, policy makers and site inspectors.),Design and Construction Practice, Guaranteed output, Reliable operation and Safety measures.

Micro Hydro Design Aids: A set of typical drawings and spreadsheet calculations useful for Nepali (MHPs) up to feasibility study level.
Focus 1: Aimed at NOT replacing the skills and knowledge of the consultants/Stakeholders.
Focus 2: Quality reports by using the saved time.

Present Status of MHPs: Quality in MHP is gradually improving from design to construction. Design & Report standards have generally improved. More experienced consultants are required.

To Conclude Improvement in quality requires constant effort from all concerned stakeholders – i.e., developer, consultant, installer, policy makers and site inspectors.

11. Analysis of Strengths, Best practices and Weaknesses of existing Micro Hydro Quality standards, Quality assurances Programs and suggestions for improvements

Quality Standards

The information relating to micro-hydro in Nepal is well documented by AEPC. Testing facilities are available in India for MH. In Sri Lanka there is a well proven mechanism but sustainability of the sector is at stake. Quality standards are in place India and Nepal. In Sri Lanka specifications are established for system as a whole and not for the components. However in India the specifications are available for components and not for the system as a whole. The micro-hydro sector in Sri Lanka is project driven and it is unlikely that the sector can survive on its own. In Sri Lanka, NERD Centre is equipped as an accreditation institution for turbines. However the Institution does not has the facility for IGC. Testing facilities are not available in Nepal.

Quality assurance

Quality assurance system is important for sustainability. In India, Sustainability of the system (Post installation) is at stake. Energy sector master Plan in Sri Lanka does not include renewable energy sector. In Nepal and India the Institutional Mechanisms for quality assurance is in place. Quality assurance is Policy driven. In Sri Lanka Provincial programs are in place for monitoring after sales services.

In India, Rural Electrification is license free to encourage private sector and there is a 90% subsidy for MH development in rural areas. Only safety aspects is certified & controlled for Indian enterprises in India.

Quality assurance training - institutional mechanisms

In Sri Lanka operation & maintenance related training is under way. It is targeted at developing skills of Electricity Consumer Societies. Training opportunities for developers in India is large. There is no accreditation for MH training. Absence of linkages with institutions in the region is a key issue that hinders progress in this sector.

12. Establishing a Framework for Quality Systems

Presentation made by Ms. Wendy Parker, Institute for Sustainable Power, Inc, USA

Quality Standards Fit into National & International Frameworks.

Government Systems: Financial Regulations; Business Regulations
Training Infrastructure: Vocational Training; Higher Education
Industry: Markets and Market Controls

Implement through Existing Frameworks and don't re-invent the wheel.
Use existing programs & institutions: Government Standards programs; Vocational training; Higher education; Professional & Industry Associations; Organized labour unions; Non-profits and NGOs

What are Quality Standards?
Performance metrics setting the bar for:
- Hardware: How hardware should perform under given conditions?
- Practitioners (PEOPLE): What people should know? What people should be able to do?
- Training: Training content; Practical exercises, examinations
- Management Systems

Training & Practitioner Standards: Components: Task Analysis - Technical Committees Develop Task Analyses; Program Requirements; Experience Requirements & Recognition Process

Task Analysis Development Process
Step 1: Define Task Analysis Scope
Step 2: Engage Stakeholders
Step 3: Establish Technical Committee & Secretariat
Step 4: Draft Task Analysis
Step 5: Expert Review, Public Comment, Stakeholder Input; Final Draft Task Analysis; Approval Core Task Analysis
Step 6: Adopt & Publish
Step 7: Maintain

1. Define the Scope
   - For what technology will the Task Analysis be developed? ie: Micro-hydro
   - For what specific job titles or tasks will the Task Analysis be developed? ie: Micro-hydro system designers?; ie: Micro-hydro system installers?; ie: Micro-hydro maintenance techs?

2. Engage Experts & Stakeholders: Representatives of Appropriate Government Ministries, Representatives of Financial Institutions, Representatives of Regulators, Inspectors, Representatives of the manufacturing / distributing Industry, Representatives of organized labour, unions, Representatives of Vocational Training, Education, Representatives of Relevant non-profits and NGOs

Engage Stakeholders! "Experience indicates that standards are accepted more positively when they are jointly developed by stakeholders and are applied voluntarily."

From: *Fretwell, David H.; Lewis, Morgan V.; Deij, Arjen. "A Framework for Defining and Assessing Occupational and Training Standards in Developing Countries." Information Series No. 386 (ERIC, World Bank, and European Training Foundation) 2001.*

3. Establish a formal Technical Committee: Subject matter experts; Key stakeholder representatives
   Establish a Secretariat: Provide support in both financial and in-kind; Facilitate the choosing of Technical Committee members and the hosting of meetings; Name the Chair for the Technical Committee; Report to the Oversight Committee at least once a year.
   What is a Technical Committee?
   - Technical Committee (TC): international group of Subject Matter Experts, working under the direction of a Secretariat; Secretariat provide physical and financial support.

4. Draft the Standard: Identify what the target practitioner DOES; Convene practitioners to describe their job; Convene stakeholders to describe their expectations of people in the job; Interview experts to identify what is done, why it is important, and when.

   4.b Organize the Standard

   The PV Installer Task Analysis has the following categories: Working safely with Photovoltaic Systems; Conducting a Site Assessment; Selecting a System Design; Adapting the Mechanical Design; Adapting the Electrical Design; Installing Subsystems & Components at the Site; Performing a System Checkout & Inspection; Maintaining & Troubleshooting

   4.c Rank the Items

   Rank each skill & knowledge item according to how imperative it is to successful job completion.

		Likelihood of Error	
		High	Low
Consequence of Error	High	Must Know	Should Know
	Low	Should Know	Might Know

4.c Task Analysis Sample

Task: skill	***Skill Type:***	***Priority important***
Working Safely with Photovoltaic Systems		
As part of safety considerations associated with installing and maintaining PV systems, any PV installer must be able to:		
Maintain safe work habits and clean, orderly work area	Cognitive, Psychomotor	Critical
Demonstrate safe and proper use of required tools and equipment	Cognitive, Psychomotor	Critical
Demonstrate proficiency in basic first aid and CPR	Cognitive, Psychomotor	Important
Selecting a System Design		
Based on results from a site survey, customer requirements and expectations, the installer shall be able to:		
Identify appropriate system designs/configurations based on customer needs, expectations and site conditions	Cognitive	Very Important
Estimate time, materials and equipment required for installation, determine installation sequence to optimize use of time and materials	Cognitive	Important

5. Subject Drafts to Review and Comment: Seek written input from; Stakeholder groups, Industry, Practitioners & Government administrators; Respond to input; Revise Draft Task Analysis

6. Formal Adoption & Publication: Revise Draft Standard until Consensus among Technical Committee Members is achieved; Vote to ratify Standard

7. Maintenance and Update: Secretariat & Technical Committee conduct regular review of the Task Analysis; Invite stakeholder comment; Incorporate stakeholder comments; Achieve consensus and vote to re-approve changed standard.

Final Task Analysis Will: Describe- Skills and Knowledge needed by a practitioner; Provide a Guide for Quality Training Programs; Provide a Guide for assessing the competency of practitioners

13. Guidelines for Establishing and Maintaining Technical Committees

Presentation by Ms. Wendy Parker, Institute for Sustainable Power, Inc, USA

What is a Technical Committee? It is an international group of Subject Matter Experts, working under the direction of a Secretariat. Secretariat provides physical and financial support.

What are a Technical Committee's Goals?

- Create technology- or application-specific Task Analyses
- Describing the skills and knowledge that a practitioner should have
- Provide detailed expertise and support to a quality standards program

Define Scope and Engage Stakeholders: Technical Committee will be specific to: A certain technology & certain job titles or "tasks" within that technology (I.e.: installer, maintenance technician, designer or inspector). Stakeholder representatives and subject matter experts make up the committee

Establish Secretariat Organization or individual responsible for hosting a Technical Committee. Provide support in both financial and in-kind. Facilitate the choosing of Technical Committee members and the hosting of meetings. Name the Chair for the Technical Committee. Report to the Oversight Committee at least once a year.

Choose Chair and Secretary; Usually, the Chair is a member of, employee of, or related to the Secretariat; Calls meetings, runs meetings; Ensures that members are present in sufficient numbers, that votes are recorded; Works closely with a Secretary; Secretary assists chair in communicating with committee members, taking minutes of meetings, etc.

Begin Work on Task Analysis: Define timeline, Assemble other relevant standards, Compose a draft, Begin consensus work, reviewing each point of draft, Adding points, Re-writing points, Interview relevant practitioners, and Observe practitioners at work

- What does an expert [of a specific technology and job title] DO? Provide Skills needed, Knowledge needed, CONTENT required for a training program, Expertise needed for an individual practitioner

Committee Operations:
Hold meetings; in person? electronically?
Use the Internet: Discussion boards, Email
Establish Timelines: When will the first draft of the Task Analysis be completed? When will it be ready for public & expert comment? When should it be finalized and ready for approval?
Define roles of committee members: Comment on proposed skill and knowledge items; Develop complete & accurate Task Analysis; Vote on versions

Action
- Begin work on Task Analysis!
- Committee Member’s comments, discussions, and votes should be recorded
- Task Analysis will go out for public comment and wider expert review
- Then Committee will vote to accept Task Analysis as final

14. Developing National Technical Committees on Micro-hydro in India

Outcomes of Group Discussions

BIS can act as the Regulator and the certifying authority for micro-hydro standards.

Micro-hydro sector Stakeholders in India
For Hardware - MNE of the government of India, State Nodal agencies for renewable Energy - Village Panchayat, Manufacturers, Planning & Design consultants, Contractors (Civil work, E/M work), and NGOs
For Software - MNE, SNAs for RE, Technical institutes (Certificate level/ Diploma level), Financial institutions (NABARD/IREDA/REC/Commercial Banks/ Cooperative Banks), Regulatory Committees Academic Research Institutes (TERI, IIT-Roorkee), NGOs, Consultants and Contractors

Secretariat in India for Technical Committee - Alternate Hydro Energy Centre (AHEC)/ IIT Roorkee)

Subject Matter Experts in India
Software Training - Project Management (Implementation): Consultants (Designers), Financiers, SNAs, Manufactures (Customer Service), End users, Masons training, Technicians and NGOs.

Proposed key steps for the formation of National Committees

- Apex body prepare the draft framework
- Identify stakeholders & their role
- organize meetings/ workshops
- operational plan -------------> Input to MNES ---------> Accreditation agency

15. Developing National Technical Committees on Micro-hydro in Nepal

Subject areas	**Institutions engaged**	**Local Experts**
Hardware		
Turbines	AEPC, REDP, ESAP ADDCN, NAVIN, NMHDA	WINROCK SHPP, Hydro consultant, BPC, IOE, KU, ITDG
Generators	Consultants	
Controller	Consultants	
Civil works (Penstock etc. weir-P/M)	NMEF, NMMDA Pipe Manufacturers	
Transmission & Distribution	Pipe Manufacturers Cable Manufacturers ESAP, WB, UNDP, Financing Institutions (ADB,RBB)	
System Quality Assurance	AEPC (TRC) - consultant - Pou Inspector - Quality Supervisor NMMDA NMHEF Donors (ESDP, WB, UNDP) AC, NGOs Financing institutions (RBB, ADB/N)	
Practitioners - Installers - Designers - operators - surveyors - Fabricators - Verifiers - Managers - Social Mobilisers	CTEUT, AEPC, NMMDA, NMHEF NMMDA AC, NGOs	IOE, KU SHPP
Coordinating body AEDC Steps for formation of TC Stakeholders consultation Formations of committee		
Financing ESAP, NMGLN, WB, UNDP		

16. Developing National Technical Committees on Micro-hydro in Sri Lanka

Subject Areas	Local Stakeholders	Experts
1. Turbines	NERD/	No
2. Generator		No
3. Controllers	NERD & 2 universities	Mr. Ajith Ratnayake Mr. P.C. Hettiarachchi
4. Cables conduits	Constructors	
5. Penstock	Constructors	
6. Civil work	Constructors	
7. Distribution system	Constructors	
8. System Design (Hydrology, electrical, Mechanical, Civil eng., O&M)	Testing by Chartered Engineers Participating - firms individuals	
9. Socio economic aspects (Analysis, Mobilizing)		
10. Feasibility business plans		
11. Construction, installation and commissioning	Testing- chartered engineers participating - firm	

Training	Organizations
Manufacturing Turbines Generator Controllers	ITDG/ University Fentons
System Designing	ITDG
PPC	ITDG/ SLBDC
Construction	ICTAD
O& M + Management	FECS/ PPC
Verification	MH Expert

Proposed coordinating body in Sri Lanka until the standards are in place will be the Energy Forum. Actual implementation of standards will be the role of Sri Lanka Standards Institution (SLS) and the Public Utility Commission of Sri Lanka (PUCSL).

Key steps
1. Nominate experts
2. Assess the capacities of NERD/ University/ Vocational Training FECS ITDG
3. Conduct Capacity Building
4. Assign responsibilities to the experts

Possible Financing for the next steps
1. USAID
2. RERED - TA (Local)
3. ADB, DANIDA, UNDP
4. KfW (Herman), JBIC

17. Developing Regional Micro-hydro Technical Committees; developing a Regional Strategy for Standards Harmonization & Participating in a Standards Secretariat and Work plan on setting up National Technical Committees and Regional Micro Hydro Standards Secretariat

Plenary discussion
Most of the countries in the region are practicing quality programs on micro hydro. Sri Lanka & Nepal have developed certain mechanisms and procedures to address the issue of standards. Gathering of available information on best practices and implementing specification check lists can be developed.

The technology serves for marginalized community in the region and their level of income is generally less than average GDP level of country. They lack basic infra-structural facilities. Priority should be given to affordability of consumers while fixing the price. It is necessary to consider safety and the ability to utilize local material and human capacities in each country. For setting up of quality standards, comprehensive of training programs for capacity building can play a major role.

There was consent that national level up-grading of standards should be the first task and then to regional harmonization.

Establishment of Regional Micro Hydro Standards Secretariat

Functions the Regional Secretariat

1. Facilitate access to information on prevailing standards specifications.
2. Identify modalities of exchanging information.
3. Facilitate expertise from countries in the Region.
4. Facilitate Resource mobilization.
5. Initiate Development of Regional Standards in areas of comparative advantage.
6. Lobbying government to Implementing quality, Funders systems and Standards.

Regional Secretariat - Energy Forum of Sri Lanka (EF)
If required the Regional Secretariat can be rotated periodically.

Focal Point in each country
Nepal - Alternative Energy Promotion Centre, Nepal (AEPC)
India - Alternative Hydro Energy Centre, India (AHEC)
Sri Lanka - Energy Forum (EF)

Composition
Three Representatives from 3 Countries and 3 alternative persons

India	- Mr. Arun Kumar, Alternative Hydro Energy Centre, India (AHEC)
	- Dr. R. P. Saini (Alternative)
Nepal	- Mr. R. P. Dhita, Alternative Energy Promotion Centre, Nepal (AEPC)
	- Mr. D.P. Adikari (Alternative)
Sri Lanka	- Mr. Asoka Abeygunawardana, Energy Forum (EF)
	- Mr. Bandula Chandrasekera (Alternative)

Possible funding agencies for future activities

SARI / Energy Phase 3
UNIDO / UNDP/ ADB

Key Activities

Activity	Responsibility	Time Frame
1. Workshop Report & a Concept Note	EF / ITDG / ISP	September. 25, 2004
2. 1st. phase (Short term) Draft national guidelines	Nepal - AHEC India - AEPC	September 2005

Setting up committees - Setting up Hardware Software Specifications Standard (Draft guidelines). - Training module development synthesizing of existing operational guidelines. Writing concept notes & Proposals National / Regional proposal to SARI -Energy.	Sri Lanka - EF	
3. 2nd Phase (Long term) **National** Adoption of standards Implementation Phase - Review, Modification Awareness creation. Enforcement Compliable and Regulation aspects Compliance Submit to the PUC & get the accreditation (Sri Lanka) **Regional** Setting up Guidelines & Regional Standards	Nepal - AHEC India - AEPC Sri Lanka - EF Network Secretariat	2005/06

Annex 1 Agenda

Day 1 - 5th September 2004

Inaugural Session

18.00 - 18.10 pm	**Lighting the Traditional Oil Lamp**
18.10 - 18.20 pm	**Opening address** - Dr. Priyantha Wijesooriya, Director, Energy Forum
18.20 - 18.50 pm	**Welcoming Remarks** -Mr. Upali Daranagama, Program Management Specialist, USAID Mission, Sri Lanka -Mr. Bikash Pandey, Winrock International (Nepal) -Dr. V. U. Ratnayake, General Manager, Energy Conservation Fund Ministry of Power & Energy
18.50 - 19.20 pm	**Workshop Rationale and Organization** Dr. Susil Liyanarachchi, Director, Energy Forum
19.20 - 20.00 pm	**Introduction of Participants**
20.00 -21.00 pm	**Dinner**

Day 2 - 6th September 2004

Technical Session 1 -	**Micro-hydro market, technology, industry, and training**
09.00 - 09.15	**Introduce expectation for the Day**
09.15 - 09.45	**Presentation 1- Quality Standards: Technology and Workforce** - Ms. Wendy Parker, Senior Policy Coordinator Institute for Sustainable Power, Inc, USA
09.45- 10.05	**Presentation 2 - Micro-hydro market, technology, industry, and training Opportunities in Sri Lanka** - Mr. Jayantha Gunesekera, ITDG (SA), Sri Lanka
10.05-10.25	**Presentation 3 - Micro-hydro market, technology, industry, and training Opportunities in India** - Mr. K. J. Dinesh, M/s Tide Technocrats Pvt. Ltd., India
10.25-10.45	**Presentation 4 - Micro-hydro market, technology, industry, and training Opportunities in Nepal** - Mr. Hari Bhakta Gautam, Nepal Micro-Hydro Manufacturers Association, Nepal
10.45 - 11.00	**Tea/ Coffee Break**

11.00 -12.15	**Problem Analysis in the Micro Hydro Sector in relation to Hardware Standards, Practitioners Standards and Training Standards and identify areas for developing regional standards.** **Group Discussion - Two groups**
12.15 - 12.45	**Group presentations in Plenary**
12.45 - 13.30	**Lunch**

<u>Technical Session 2 - Micro-hydro Standards, Quality Programs and Quality Systems</u>

13.30 -14.00	**Presentation 1- Existing Standards and Quality Programs in the Region** - Ms. Wendy Parker, Institute for Sustainable Power, Inc, USA
14.00 - 14.15	**Presentation 2 - Standards and Quality Programs in Sri Lanka** - Mr. Jayantha Nagendran, RERED Project, Sri Lanka
14.15 -14.30	**Presentation 3 - Standards and Quality Programs in India** - Mr. Arun Kumar, Alternate Hydro Energy Centre, IIT Roorkee
14.30 - 14.45	**Presentation 4 - Standards and Quality Programs in Nepal** - Mr. Ram Prasad Dhital, Alternative Energy Promotion Centre, Nepal
14.45 - 15.00	**Tea/coffee Break**
15.00 - 16.00	**An Analysis of Strengths, Best practices and Weaknesses of existing Micro Hydro Quality standards, Quality assurances Programs and suggestions for improvements.** **Group Discussion- Two groups**
16.15 - 16.45	**Group presentations in Plenary**
16.45 - 17.00	**Review & close Day 2 -** Mr. Jayantha Gunasekara, ITDG (SA), Sri Lanka, Mr. Arun Kumar, Alternate Hydro Energy Centre, IIT Roorkee

<u>Day 3 - 7th September 2004</u>

<u>Technical Session 3 - Establishing a Technical Committee</u>

9.00 - 9.20	**Presentation 1 - Establishing a Framework for Quality Systems** - Ms. Wendy Parker, Institute for Sustainable Power, Inc, USA
9.20 - 9.45	**Review on Adaptation of the Framework to suit the Regional Context/Reality as surfaced during group works.**

	- Panel Discussion- Mr. Bikash Pandey, Winrock International (Nepal) Mr. K. J. Dinesh, M/s Tide Technocrats Pvt. Ltd., India Mr. S. M. G. Samarakoon, Director, CAPS
9.45- 10.15	**Presentation 2 - Guidelines for Establishing and Maintaining Technical Committees** **-** Ms. Wendy Parker, Institute for Sustainable Power, Inc, USA
10.15- 10.30	**Clarifications**
10.30- 10.45	**Tea / Coffee break**
10.45 -11.30	**Developing National Technical Committees on Micro-hydro** **Group Discussions -** (Three Groups- Sri Lanka, India & Nepal**)**
11.30 - 12.00	**Presentations in Plenary**
12.00 -12.30	**Review on Presentations, Comments & Suggestions** **-** Ms. Wendy Parker, Institute for Sustainable Power, Inc, USA
12.30 - 13.30	**Lunch**
13.30 - 14.30	**Developing Regional Micro-hydro Technical Committees; developing a Regional Strategy for Standards Harmonization & Participating in a Standards Secretariat** Group Discussions - Two groups
14.30 - 15.00	**Presentations in Plenary**
15.00 - 15.30	**Review on Presentations, Comments & Suggestions** **-** Ms. Wendy Parker, Institute for Sustainable Power, Inc, USA
15.30 - 15.45	**Tea/Coffee break**
15.45 - 16.30	**Draft follow-up work plan on setting up National Technical Committees and Regional Micro Hydro Standards Secretariat** **- Open Discussion-** Ms. Wendy Parker, Institute for Sustainable Power, Inc, USA Mr. Asoka Abeygunawardane, Energy Forum
16.30 - 16.45	**Formal Close of Workshop**

Annex 02: List of Participants

No	Name	Organization
1.	Mr. Hari Bakta Gautam	Gutam Engineering Industries, Nepal
2.	Mr. Ram Prasad Dhital	Alternative Energy Promotion Centre, Nepal
3.	Mr. Bir Bahadur Ghale	Federation of Nepal Micro-Hydro Association Nepal
4.	Mr. Arun Kumar	Alternative Hydro Energy Centre, India
5.	Mr. K.J.Dinesh	Tide Technocrats Pvt. Ltd India
6.	Mr. Bikash Pandey	Winrock International, Nepal
7	Ms. Wendy Parker	Institute for Sustainable Power, Inc. USA
8.	Mr. Upali Daranagama	USAID - Colombo
9.	Dr. V.U.Ratnayaka	Energy Conservation Fund
10.	Ms. Sanjeewani Munasinghe	British Council
11.	Dr. Priyantha Wijesooriya	Energy Forum
12.	Mr. Jayantha Gunasekara	ITDG South Asia
13.	Mr. Jayantha Nagendran	RERED Project
14.	Mr. Ranil Senaratne	Fentons (Pvt) Ltd
15.	Mr. T.A. Wickramasinghe	NERD Centre
16.	Mr. P.C. Hettiarachchi	System Engineers
17.	Mr. Tony Kalupahana	REDCO/VISMA
18.	Dr. Nishantha Nanayakkara	ENCO (Pvt) Ltd
19.	Mr. S.M.G. Samarakoon	CAPS
20.	Mr. Cyril Gunathilaka	Federation of Electricity Consumer Societies
22.	Mr. Damitha Kumarasinghe	Public Utility Commission
23.	Mr. Shanaka Fonseka	Hatton National Bank
24	Ms. Madawi Ariyabandu	ITDG-South Asia
25	Mr. Asoka Abeygunawardana-	Energy Forum
26	Mr. Bandula Chandrasekara	Energy Forum
27	Mr. Y.P. Dasanayaka	Federation of Electricity Consumer Societies
29.	Dr. Susil Liyanarachchi	Energy Forum
30.	Ms. Wathsala Herath	Energy Forum

Annex 03: Objectives and Task Analysis for the Micro Hydro System Installer Technician

(Maintenance Technician is a Subset of the Installer Task Analysis, Sect. 1 & 8)

Introduction

This document presents an in-depth task analysis for practitioners who specify, install and maintain Micro Hydro power generation systems and equipment (MHS). This task analysis was developed through extensive interviews and relationships with contractors, manufacturers, trade organizations, codes and standards developers, and educators, and includes significant input from subject matter experts in the field. Numerous experiences from the evaluation of installations, maintenance requirements, and the performance and reliability of MHS systems were also heavily considered in the development of these tasks.

Purpose

The purpose of this task analysis is to define a general set of competencies or skills typically required of practitioners who install and maintain Micro Hydro Systems. Specifically, the task analysis helps establish the basis for training curricula and helps define requirements for the assessment and credentialing of practitioners. These tasks, or modified version thereof, may be used as guidelines for states or organizations that wish to train, test, certify or otherwise qualify existing or new workers to install Micro Hydro Systems. The principal goals of these efforts are to help develop an accredited training infrastructure that produces a knowledgeable, skilled and experienced workforce, and thus helps to ensure the safety, quality and consumer acceptance of PV installations.

Scope

This task analysis is intended to be all-inclusive of the skills expected for any qualified MHS installer, and does not differentiate skills or experience that may be common among existing tradespersons. Furthermore, this list only defines what the tasks are, not how they are accomplished – these issues are mainly dealt with through training and assessment mechanisms. In general, these tasks include fundamental electrical skills, as well as special skills related to Micro Hydro technology and its application. Although these tasks are primarily targeted toward the installer as opposed to the system designer, in many cases the installer must be knowledgeable about many aspects of systems design, and may be required to adapt designs and equipment to fit a particular application or customer need. They often are required to select and specify balance-of-system (BOS) components. For these reasons, the task analysis includes several items involving the verification of the system designs. Electrical codes, safety standards, and accepted industry practice are central to this task analysis, and are implicit to nearly every task. Fundamentally, these tasks assume that the installer begins with adequate documentation for the system design and equipment, including manuals for major components, electrical and mechanical drawings, and instructions. While these tasks have been developed based on conventional designs, equipment and practice used in the industry today, they do not seek to limit or restrict innovative equipment, designs or installation practice in any manner. As with any developing technology, it is fully expected that the skills required of the practitioner will develop and change over time, as new materials, techniques, codes and standards evolve.

Classifications

Specific tasks in this document are classified as either ***cognitive*** (knowledge) or ***psychomotor*** (hands-on) skills for the purposes of identifying the types of training and assessment methods that generally apply: ***Cognitive*** skills require knowledge processing, decision-making and computations, and can generally be assessed by a written examination. ***Psychomotor*** skills require physical actions and hand-eye coordination such as fastening, assembling, measuring, etc, and more appropriately assessed though qualified experience. The tasks are also ranked according to their priority or importance: ***Critical*** items are considered high priority tasks, and are expected competencies for all MHS installers. These include items involving safety and other tasks with a high consequence and high chance of error. ***Very Important*** items are medium priority tasks, and are generally expected of all competent installers. ***Important*** items are considered lower priority tasks, but usually performed by the quality installer.

Primary Objectives for the Micro Hydro System Installer

Given basic instructions, major components, schematics and drawings, the MHS installer is required to specify, configure, install, inspect and maintain a Micro Hydro System that meets the performance and reliability needs of the customer, incorporates quality craftsmanship, and complies with all applicable safety codes and standards by:

1. Working Safely With Micro Hydro Generator Systems
2. Conducing A Site Assessment
3. Selecting A System Design
4. Adapting The Mechanical Design And Installation
5. Adapting The Electrical Design
6. Installing Subsystems And Components At The Site
7. Performing A System Checkout And Inspection
8. Maintaining And Troubleshooting System
9. System Life Cycle Costing Analysis

1	***Working Safely with Micro Hydro Generators***		
	Task/Skill:	*Skill type:*	*Priority*
	As part of normal safety considerations, any Micro Hydro Generators system installer and operator must be able to:		
1.1	Identify electrical and non-electrical hazards associated with Micro Hydro Generators system installations, and implement preventative and remedial measures to ensure personnel safety.	Cognitive	Critical
1.2	Maintain safe work habits and clean, orderly work area.	Cognitive, Psychomotor	Critical
1.3	Demonstrate proper use of tools and equipment.	Cognitive, Psychomotor	Critical
1.4	Demonstrate safe and accepted practices for personnel protection.	Cognitive	Critical
1.5	Demonstrate awareness of safety hazards and how to avoid them.	Cognitive	Critical
1.6	Demonstrate proficiency in basic first aid and CPR.	Cognitive, Psychomotor	Critical
1.7	Identify and implement appropriate codes and standards concerning installation, operation and maintenance of MHS and equipment.	Cognitive	Critical
1.8	Identify and implement appropriate codes and standards concerning worker and public safety.	Cognitive,	Critical
1.9	Identify personal safety hazards associated with MHS installations, and implement preventative and remedial measures.	Cognitive,	Critical
1.10	Identify environmental hazards associated with MHS installations, and implement preventative and remedial measures.	Cognitive	Critical
2	***Conducting a Site Survey***		
	Task/Skill:	*Skill Type*	*Priority*
	In conducting site surveys for Micro Hydro Generator systems, the installer shall be able to:		
2.1	Display an understanding of the relevant terminology, such as potential kinetic energy, gross head, net head and flow rate	Cognitive	Very Important
2.2	Display an understanding of correct units for energy and power, vis. Watts (W), Volt Amperes (VA), Mega Joules (MJ), kilo watt hours (kWh) and the commonly used term amp hours (Ah)	Cognitive	Critical
2.3	Identify typical tools and equipment required for conducting site surveys for Micro Hydro Generator system installations.. Demonstrate proficiency in their use. Dumpy level or theodolite, altimeter, pressure gauge and contour map. Compare the accuracy, advantages and disadvantages of each head assessment.	Cognitive Psychomotor	Critical
2.4	Measure the flow rate using each of the following methods – catchment	Cognitive	Critical

	area calculations, water diversion to fill a container, stream velocity/area measurement, and weir construction method.	Psychomotor	
2.5	State the advantages and disadvantages of each method of flow measurement with particular reference the their accuracy	Cognitive	Very Important
2.6	Identify environmental constraints at the site including minimal flow rates, ecological impacts, and visual and noise impacts	Cognitive	Critical
2.7	Identify government regulatory requirements such as those covered under the water resources or environmental legislation	Cognitive	Very Important
2.8	Establish a suitable location with proper flows, sufficient static head, adequate flood levels and structural integrity for installing the Micro Hydro Turbine	Cognitive Psychomotor	Critical
2.9	Establish suitable locations for installing control, batteries and other balance-of-system components	Cognitive	Critical
2.10	Diagram possible layouts and locations for the Micro Hydro turbine and equipment, including existing building or site features	Cognitive Psychomotor	Very Important
2.11	Identify and assess any site-specific safety hazards or other issues associated with installation of Micro Hydro Generator system	Cognitive	Critical
2.12	Obtain and interpret long term rainfall and temperature data for the site. Establishing performance expectations and determine viable long-term flow rates.	Cognitive	Critical
2.13	Quantify the customer electrical load and energy use through review of utility bills, meter readings, measurements and /or customer interview, as required. Describe the effects of daily and seasonal demands on the system sizing	Cognitive	Critical
2.14	Estimate and /or measure the peak load demand and average daily energy use for all loads directly connected to battery system for purposes of sizing equipment, as applicable	Cognitive	Critical
2.15	Identify opportunities for use of energy efficient equipment/appliances, conservation & energy management practices, as applicable	Cognitive	Very Important
3	***Selecting a System Design***		
	Task/Skill:	*Skill Type*	*Priority*
	When selecting a micro hydro system design the practitioner shall be able to:		
3.1	Describe the structural differences between the Pelton, Turbo Impulse, Francis, Mitchell or cross flow Turbines.	Cognitive	Critical
3.2	Show the system configuration for each turbine type and identify all major components. Compare the operational parameters and efficiency of each turbine.	Cognitive	Critical
3.3	Outline the respective merits and suitability of various turbines types for various MHS applications.	Cognitive	Very Important
3.4	Describe the circumstance in which a battery bank is incorporated in the system.	Cognitive	Critical
3.5	Describe the advantages and disadvantages of water storage systems compared with other energy storage system such as battery banks.	Cognitive	Very Important
3.6	Calculate friction loss in delivery pipes using manufactures data.	Cognitive	Critical
3.7	Identify appropriate system designs and configurations based on customer needs, expectations and site conditions to suit loads, hydraulic head and stream flow characteristics.	Cognitive	Critical
3.8	Calculate the energy output of the selected MHS at the site from water flow rates, head and manufactures data, allowing for season variations in performance.	Cognitive	Critical
3.9	Describe the design of any required weirs or dams, open races or penstocks, strainer and intake systems.	Cognitive	Very Important
3.10	Estimate sizing requirements for major components based on customer load, desired energy or peak power production, autonomy requirement, size and costs as applicable.	Cognitive	Critical
3.11	Identify and select major components and balance of system equipment required for installation including delivery pipes and fittings, transmission cables and voltage, voltage and frequency regulation, battery storage type and capacity, battery charger, inverter, back-up generator and load dump.	Cognitive	Critical
3.12	Determine the type of electrical transmission configuration, such as	Cognitive	Critical

	underground or overhead, according to distances, topology and local regulations.		
3.13	Estimate time, materials and equipment required for installation, determine installation sequence to optimise use of time and materials.	Cognitive	Very Important
3.14	Outline the likely environmentally impacts of the MHS installation and appropriate actions to minimise these impacts.	Cognitive	Very Important
4	***Adapting the mechanical design and installation***		
	Task/Skill:	*Skill Type*	*Priority*
	In adapting a Micro Hydro Generator system mechanical design, the practitioner shall be able to:		
4.1	Identify a mechanical design and installation plan that is consistent with the environmental, architectural, structural, code requirements and other conditions of the site.	Cognitive	Critical
4.2	Identify an appropriate MHS taking into account the topology of the site, local authorities' approvals, environmental considerations, site access and transport of equipment, water and power transmissions distances and daily and seasonal load profiles. Other factors include method of construction of civil works and ease of installation, electrical configuration and maintenance at the site.	Cognitive	Critical
5	***Adapting the electrical design***		
	Task/Skill	***Skill Type***	***Priority***
	In adapting a Micro Hydro Generator system electrical design, the practitioner shall be able to:		
5.1	Determine the design currents for any part of a Micro Hydro Generator system electrical circuit.	Cognitive	Critical
5.2	Select appropriate conductor types and ratings for each electrical circuit in the system based on application.	Cognitive	Critical
5.3	Determine the de-rated ampacity of system conductors, and select appropriate sizes based on design currents.	Cognitive	Critical
5.4	Determine appropriate size, ratings and locations for all system over current and disconnect devices.	Cognitive	Critical
5.5	Determine appropriate size, ratings and locations for grounding, surge suppression and associated equipment	Cognitive	Critical
5.6	Determine voltage drop for any electrical circuit based on size and length of conductors	Cognitive Psychomotor	Critical
5.7	Verify that the operating voltage range is within acceptable operating limits for power conditioning equipment, including inverters and controllers	Cognitive Psychomotor	Critical
6	***Installing the subsystem and components***		
	Task/Skill	*Skill Type*	*Priority*
	As part of the Micro Hydro Generator system installation process, the practitioner shall be able to:		
6.1	Utilize drawings, schematics, instructions and recommended procedures in installing equipment.	Cognitive Psychomotor	Critical
6.2	Implement all applicable personnel safety and environmental protection measures.	Cognitive Psychomotor	Critical
6.3	Visually inspect and quick test turbine components as required.	Cognitive Psychomotor	Critical
6.4	Install and label inverters, controls, disconnects and over current devices, surge suppression and grounding equipment, junction boxes, batteries and enclosures, conduit and other electrical hardware as required.	Cognitive Psychomotor	Critical
6.5	Label, install and terminate electrical wiring, verify proper connections, voltages and phase/polarity relationships.	Cognitive Psychomotor	Critical
6.6	Verify continuity and measure impedance of grounding system as required.	Cognitive Psychomotor	Critical
6.7	Program, adjust and/or configure inverters and controls for desired set points and operating modes as required.	Cognitive Psychomotor	Critical
6.8	Install and inspect all load wiring, receptacles and fixtures, switches and appliances.	Cognitive Psychomotor	Critical
7	***Performing commissioning and inspection***		

	Task/Skill:	Skill Type	Priority
	After completing the installation of a Micro Hydro Generator system, as part of system commissioning, inspections and handoff to the owner/operator, the practitioner shall be able to:		
7.1	Visually inspect entire installation, identifying and resolving any deficiencies in materials or workmanship.	Cognitive Psychomotor	Critical
7.2	Check system mechanical installation for structural integrity and weather sealing as required.	Cognitive Psychomotor	Very Important
7.3	Check electrical installation for proper wiring practice, polarity, grounding and security of terminations.	Cognitive Psychomotor	Critical
7.4	Activate system and verify overall system functionality and performance; compare with expectations.	Cognitive Psychomotor	Very Important
7.5	Demonstrate correct sequence for system activation and stop, connecting and disconnecting the system and equipment from all sources.	Cognitive Psychomotor	Critical
7.6	Identify and verify all markings and labels for system and equipment as required.	Cognitive	Very Important
7.7	Identify and explain all safety issues associated with operation and maintenance of system.	Cognitive	Critical
7.8	Transfer a complete documentation package for the system and equipment to owner/operator.	Cognitive	Critical
7.9	Explain the proper use method of electrical application and basic knowledge, safety consideration, and limitations of the Micro Hydro Generator system.	Cognitive	Very Important
8	***Maintaining and troubleshooting system***		
	Task/Skill:	*Skill Type*	*Priority*
	In maintaining and troubleshooting a Micro Hydro Generator system, the practitioner shall be able to		
8.1	Identify tools and equipment required for maintaining and troubleshooting *Micro Hydro Generator systems;* demonstrate proficiency in their use.	Cognitive Psychomotor	Very Important
8.2	Identify maintenance needs and implement service procedures for system, weirs, penstock, intake systems, turbines, batteries, power conditioning equipment, safety systems, structural and weather sealing systems, and balance of systems equipment.	Cognitive Psychomotor	Critical
8.3	Measure system performance and operating parameters, compare with specifications and expectations, and assess operating condition of system and equipment.	Cognitive Psychomotor	Very Important
8.4	Perform diagnostic procedures and interpret results.	Cognitive Psychomotor	Critical
8.5	Identify performance and safety issues, and implement corrective measures.	Cognitive Psychomotor	Critical
8.6	Verify and demonstrate complete functionality and performance of system, including start-up, shut-down, normal operation and emergency/bypass operation.	Cognitive Psychomotor	Critical
8.7	Compile and maintain records of system operation, performance and maintenance.	Cognitive	Very Important
9	***System life cycle costing analysis***		
	Task/Skill:	*Skill Type*	*Priority*
	When Analysing the life cycle costing of a micro hydro system design the practitioner shall be able to		
9.1	Describe the major cost to be considered in the life cycle costing method.	Cognitive	Very Important
9.2	Calculate the capital and life cycle cost that includes the cost of various system configuration for micro hydro application.	Cognitive	Very Important
9.3	Examine the external cost that may impact on the effectiveness of a MHS.	Cognitive	Very Important
9.4	Select the most cost effective of a number of options base on the life cycle analysis.	Cognitive	Very Important