

***ENERGY FOR RURAL DEVELOPMENT IN  
AFGHANISTAN***

***ANNUAL REPORT 2008***



***ENERGY FOR RURAL DEVELOPMENT IN AFGHANISTAN (ERDA)  
NATIONAL AREA BASED DEVELOPMENT PROGRAM (NABDP) UNDP  
MINISTRY OF RURAL AND REHABILITATION DEVELOPMENT (MRRD)***

**AFGHANISTAN**

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## 1 Background

Access to reliable and affordable energy services is a necessary precondition for sustainable development and rural poverty reduction. Given that over 75% of the population in Afghanistan is estimated to be rural, the provision of modern energy services in rural areas will play a critical role in meeting the country's Millennium Development Goals (MDGs). Lack of energy services means that children cannot study in the evening and health care options are limited at primary health centers. Girls and women spend an average of 3-4 hours per household per day in rural Afghanistan collecting fuel and more time for collecting and carrying water. Animal dung is being burned as fuel instead of used as agricultural input. Only around 25 percent of the population in the country, mainly residing in urban areas, is estimated to have access to electricity. In rural areas, only 15 percent of the population has access to electricity. Lack of access to reliable and affordable power is an important barrier to private investments into micro, small and medium enterprises (MSMEs) in provincial and district markets outside the major cities. This has serious ramifications as it is these very MSMEs which promise to be the catalyst to mass rural employment and major generators of legitimate employment opportunities (with implication to the social reintegration of ex-combatants and other marginalized individuals) and to counter the illicit narcotics economy. Insufficient availability of reliable energy also means that livelihood opportunities are lost through inability to create value addition for local agricultural produce.

Surveys have shown repeatedly that energy, particularly electricity, is high on the list of priorities of the Afghan people. Rural communities have ranked energy projects second after water projects within the MRRD's National Solidarity Programme (NSP). Almost all District Development Plans (DDPs) include rural electrification projects.

Afghanistan has significant renewable energy resources that could meet the needs of the scattered rural population – providing energy for livelihoods, education for girls and boys, reducing household burden for women, improving indoor health standards and contributing to overall environmental protection. There is currently insufficient capacity at the level of government ministries and departments, DDAs, CDCs, user groups, NGOs and private sector suppliers to develop these resources to their full potential and provide energy services to rural communities in a sustainable manner.

The Ministry of Energy and Water (MEW) and Ministry of Rural Rehabilitation and Development (MRRD) are active in promoting rural energy/electrification in Afghanistan. Provincial Power Departments under MEW continue to distribute power from existing small hydro and diesel generators in provincial town centers. Many of the Power Department generators and distribution networks are overloaded, generally in poor condition and in serious need of a sustained operations and maintenance scheme.

MRRD, through National Solidarity Program (NSP), has been the main player in promoting rural electrification in Afghanistan. NSP has supported the rural communities to install more than 600 micro hydropower plants and another 600 are at various stages of installation. Likewise, NSP has provided financial assistance to install about 100,000 solar home systems and 1700 diesel generators. NSP is actively increasing energy access to rural areas and has provided over \$50 M to communities for energy projects.

In spite of the impressive strides made in the past few years in the rural energy sector, especially in promoting micro hydropower for rural electrification, problems with project implementation and system performance have been noted. Studies have identified problems in project selection, design, execution, monitoring and management and linking energy production to enhancing livelihoods mechanisms. The micro hydro program was initiated to address an immediate and compelling need to increase access to rudimentary electricity service in rural Afghanistan, in recognition that the national electricity utility would not be in a position to respond to rural electricity demand for many years to come. Emphasis was on installing large number of systems in a short period to demonstrate the validity of the program to the rural population. With regards to the immediate goals that were established by NSP, the micro hydropower program has been quite successful. However, the problems that have been noted over the last several years have not subsided, which suggests that there is a need for a change in orientation. System planning, technical design and quality of hardware, oversight of implementation activities, and support to the communities for long term system operations and sustainability all need improvement. Rural electrification projects, whether they employ conventional or renewable technologies, require robust engineering, cost control, contractor oversight, a great deal of training and technical assistance, and professionalism in provision of service post-installation. Any micro-hydro program needs to place increased emphasis on project planning, quality of equipment and construction; training and support for

operation of generation and distribution services and productive uses of electricity.

In this context, providing access to electricity to 25% of the rural population by 2010 as envisaged by the Afghanistan Compact is a big challenge. Furthermore, the Afghanistan National Development Strategy (ANDS) sees rural energy development as a means for poverty reduction and improvement of livelihoods in the rural areas of the country, which requires reorientation in project formulation and implementation. Remoteness, dispersed settlement patterns, lack of institutions and resources required make it a daunting task. ANDS foresees the biggest challenge in addressing effective rural energy needs is to find innovative ways to couple energy service delivery with economic activities.

To help realize the priority of the Government of Afghanistan, MRRD with UNDP's supported launched Energy for Rural Development for Afghanistan (ERDA) project to contribute to the strategic energy benchmark set by Afghanistan Compact and ANDS. It was envisaged that ERDA would contribute to sustainable livelihoods and management of the environment and natural resources.

## **2 Project Strategy**

The main strategy of ERDA is to:

- a) Demonstrate successful community based models for energy supply in rural Afghanistan at different levels of governance.
- b) Build capacity for operation and management of rural energy systems at the community level; decentralized planning, and implementation monitoring of sustainable energy projects at the district level and planning, survey, design and policy formulation related to rural energy in MRRD.
- c) Expand the technological options in Afghanistan for rural energy services.
- d) Prepare a platform for MRRD/Government of Afghanistan to scale these models up to the national level in other provinces in Afghanistan.

Pilot energy projects are implemented in districts which have identified energy projects as a priority. The capacity of the DDA and relevant departments within MRRD are built up in the process of carrying out the pilot projects. The models demonstrated by the pilot projects will be scaled up in a subsequent follow up project to cover multiple provinces and districts to increase access to energy services and improve linkages to achieve wider MDG outcomes (productive employment, health, education, gender, maternal and child health, etc).

## **3 Expected Project Outputs**

Main project outputs in 18 months (as given in the project document):

- a) **Pilot energy projects:** Pilot community energy projects established in 7 community areas covering 1500 households, and sustainability concerns addressed, such as, technical and financial viability, community ownership, improved socio-economic condition and technical services system;
- b) **Capacity development:** Capacity built for coordination, project identification, planning, implementation, monitoring and sustainable operation of energy systems and services at different levels of governance (sub-CDC, CDC, CCDC ,DDA and MRRD);
- c) **Policy review:** Policies and strategies clarified on renewable energy development and use in Afghanistan.

## 4 ERDA Activities

ERDA activities commenced from February 2008 with the preparation of 18 months' (project duration) and annual work plans. The total budget in the project document was US\$ 2.7 M for the 18 months out of which US\$ 1.7 was budgeted for 2008. However, as there was no budget allocation specifically for ERDA, the workplan had to be changed several times to be commensurate with the available resources from different sources within NABDP.

### 4.1 Pilot Energy Projects

The first activity undertaken by ERDA was to review and analyze energy projects included in the District Development Plans. Based on availability of resources, security situation, accessibility and envisaged demonstration effects, energy projects were short listed for further investigation.

**Micro Hydropower Projects:** Given the fact that micro hydropower is the most widely disseminated renewable energy technology in Afghanistan and there are many problems associated with its sustainability, ERDA decided to focus on supporting the communities to install and operate MHP in selected provinces taking into consideration the long term financial and technical viability.

Accordingly, pre-feasibility studies were carried out in 54 potential micro hydropower sites in 9 provinces. Prefeasibility surveys in Bamiyan and Badakhshan were carried out per ERDA work plan whereas in other provinces were carried out per the request of MRRD or other NABDP components. The list of sites where pre-feasibility studies were undertaken is given in Annex 1. Based on the outcome of the pre-feasibility studies and availability of funding, detailed studies were undertaken in 32 potential sites and 9 project proposals were prepared

for development. The list of projects where detailed study conducted is in Annex 2.

On the request of Inter-Ministerial Committee on Hydropower, ERDA also undertook preliminary investigation of five small and mini hydropower projects to be developed with the financial assistance of Asian Development Bank. The list of projects investigated is in Annex 3.

ERDA is supporting communities in Bamyan and Badakhshan provinces to install 9 micro hydropower projects. ERDA provide technical assistance and oversight. List of projects under construction with ERDA support is in Annex 4.

**Biogas:** ERDA planned to support the communities in the border districts of Nangrahar Province to install and operate household biogas plants. ERDA undertook a preliminary survey in the area found it to have large potential. However, the program could not be implemented due to security situation. ERDA plans to install about 50 biogas plants near Jalalabad as demonstration plants. It is expected that biogas from animal waste will replace the use of fuel wood to a large extent and help protect the environment, reduce indoor air pollution, save time and labor and alleviate drudgery among women and children in fuel wood collecting.

**Standardization and Quality Assurance:** To ensure quality and sustainability of micro hydropower plants, ERDA has prepared a concept paper on standardization and quality control related to micro hydropower development in Afghanistan. ERDA will prepare technical standards and quality control mechanisms including pre-qualification of equipment supplier and installer, survey and design services providers, etc. in 2009. ERDA has prepared the following guidelines and formats related to standardization and quality control to ensure sustainability of micro hydropower projects. These documents are included in the following annexes:

- i. Identification Study Format for Micro hydro - Annex 5
- ii. Detailed Feasibility Study Format for Micro hydro – Annex 6
- iii. Technical Guidelines For Feasibility Study of MHP Projects - Annex 7
- iv. ERDA Implementation Guideline - Annex 8
- v. MHP Operation and Maintenance Plan - Annex 9
- vi. Format for Price Collection for MHP Components - Annex 10
- vii. Power Output Testing Kit - Annex 11

- viii. Design Aspects of Solar Pumping Project - Annex 12
- ix. Feasibility Study Format for Solar Pumping - Annex 13
- x. Feasibility Study Format for Biogas - Annex 14

## 4.2 Capacity Development

ERDA has prepared a capacity development needs for promotion of sustainable rural energy systems at various levels. The focus at the community level is to install, operate and manage energy plants. At the district level, focus is on enhancing the capacity of DDAs to monitor and supervise community level activities and to prepare rural energy development plans. ERDA is supporting Rural Energy and Enterprise Department (REED) and Rural Infrastructure and Technical Services Department (RITS) at the central level. The list of capacity development activities is in Annex 15.

**Community Level:** ERDA is supporting all communities where it is assisting in installation of rural energy systems to build their capacities to plan, install and operate rural energy systems. ERDA guidelines emphasize involvement of both women and men in planning, installation and operation and management of energy systems. Community members are trained as local mobilizers to mobilize fellow beneficiaries to form Micro Hydro Functional Groups to install and operate the systems. Likewise, community members identified by the community itself are trained to operate and manage energy systems. Besides, ERDA also supports the community to install and operate electricity-based micro enterprises to ensure the financial viability of the power plant and provide basic services in the rural areas.

**District Level:** ERDA is supporting the District Development Assemblies (DDA) of four districts (Bamyan Center and Yakawlang of Bamyan and Zebak and Wakhan of Badkshshan) to establish Rural Energy Cells that are responsible for planning and managing rural energy development activities. ERDA provides financial assistance to DDAs to hire technicians who supervise and provide technical assistance to the Community Development Councils (CDCs) that are installing and operating energy systems. ERDA also supports the DDA in preparation of rural energy plans. To orient DDA members on different renewable energy technologies, ERDA has prepared a brochure in Dari language which is in Annex 16.

**Central Level:** ERDA has been supporting REED and RITS of MRRD. The focus of support for REED is on energy planning and policy and for RITS

is on technical capability to survey and design rural energy projects. RITS engineers have been working closely with ERDA professionals in this regards. ERDA is supporting REED to assess the performance of micro hydropower plants installed with MRRD's support. ERDA helped prepare the questionnaires, trained technicians on power measurement and performance assessment of plants and consumer satisfaction. ERDA and REED technicians are surveying power plants in different provinces.

### 4.3 Policy Support

ERDA is supporting MRRD in formulating rural energy policies. ERDA provided comments on the draft of Afghanistan National Development Strategy (ANDS), Energy Sector Strategy, particularly on issues related to rural energy. ERDA has also prepared the draft of Micro Hydropower Development Policy for MRRD. See Annex 17 for the draft Micro Hydropower Policy document.

ERDA is working as the focal agency within MRRD and is supporting it for active participation on Inter Ministerial Commission on Energy (ICE) and ICE Sub-Committee for Renewable Energy and Rural Electrification. ICE is the highest authority in Afghanistan for energy policies and coordinating activities of all actors involved in the sector.

ERDA has also been playing critical role in mobilizing resources on behalf of MRRD. ERDA has actively participated in Inter Ministerial Committee on Hydropower coordinated by Ministry of Finance and with representation from MRRD, MEW and Asian Development Bank.

As ERDA does not have earmarked budget to implement energy projects in its programme areas, proposals were prepared and submitted to Korean government (KICA), JICA, Government of Japan, Spanish Government, Ministry of Finance, ADB,UNDP/UNAMA,UNDP/MDG Project.

ERDA is supporting MRRD to consolidate rural energy activities undertaken by various departments and programs within the ministry. External consultants were hired to recommend organizational structure and implementation modalities for rural energy development. Recommendations include consolidation of energy activities under a national rural energy development program that will not only implement rural energy projects but also develop and implement a quality control mechanism, support in developing capacities at all

level, develop mechanisms for management of plants at the community level and modalities for acquiring services through sub-contractors and mobilize necessary resources. ERDA will focus more extensively in these activities in future.

## 5 Lessons Learnt

- **Community Mobilization** undertaken previously for development activities like building irrigation canals, school, roads, etc. is not adequate for installation and operation of rural energy systems, which are technically complex. Extensive community mobilization is thus required for active participation of both men and women in installation and operation of energy systems. The ERDA implementation modality has established the positions of Local Mobilizers from among community members to mobilize the community and to orient them on their roles and responsibilities and support provided by ERDA. Local Mobilizers are trained by ERDA Community Mobilizers and other personnel.
- **DDAs** are still in the early stage of development and it is difficult to work with them. They lack permanent offices and personnel, and as most of their members live in their own villages it is difficult to communicate with them. However, DDAs are a potent vehicle for promoting rural development in Afghanistan. ERDA is supporting DDAs to undertake decentralized energy planning so that the exercise results in identification of more meaningful projects rather than mere 'wish list'. More importantly, ERDA is supporting the institutionalizing of rural energy development activities within DDAs by helping to establish a Rural Energy Cell that will be responsible for both decentralized energy planning and providing technical assistance to community managed energy systems. ERDA has established a position of technician for every DDA it works with to monitor and supervise construction work and facilitate energy planning. Though this mechanism is still evolving and needs to be assessed, it could be the foundation upon which future NABDP and other development activities could be built. Provisioning specialized cells within DDA and helping build their capacity could be a means for sustainable rural development in Afghanistan.
- **Manufacturers** and other service providers involved in rural energy technologies in Afghanistan require further training and capacity enhancement in survey, design, fabrication, installation, etc. specific capacity development activities targeting these

organizations/individuals needs to be incorporated and budgeted in the program.

- **Budget** for ERDA was allocated in the project document but not earmarked, which led to several revisions of the workplan. This affected timely execution of several critical project activities. Moreover, most of the budget in NABDP is earmarked for certain provinces with poor security situations and ERDA could not make use of it. As mentioned above, installation and operation of renewable energy systems, particularly micro hydropower projects is technically complex and requires continuous monitoring and support to the communities. ERDA personnel need to make frequent visits to the project sites. On the other hand, in many provinces where the security situation is better and there are a lot of potential sites for development budget was not available. Thus, earmarking funding to ERDA and not to particular geographical locations will help in preparing programs based on needs and potentials.

## Annexes

<b>Annex 1- Pre-feasibility of Micro Hydro Power Projects</b>						
No	Province	District	Village	No of families	Expected power output (kW)	Cost Estimate (USD)
1	Badakhshan	Ishkashem	Ghaharan	20	45	144,000
2			Bazgir	210	20	64,000
3			Andaj	34	5	16,000
4			Shakhauer	78	12	38,400
5			Sareshkhauer	51	5	16,000
6			Wurgan Payan	39	4	12,800
7			Wurgan Bala	42	5	16,000
8			Sarkand	32	5	16,000
9			Kurt	110	15	48,000
10			Badar bun	44	9	28,800
11			Gouran Bala	320	40	128,000
12		Zebak	Farooq	50	7	22,400
13			Razrok	140	20	64,000
14			Dashti Khan,	172	20	64,000
15		Wakhan	Qazedah, Wark, Kashni Khan	378	45	144,000
16			Shakhauer	78	12	38,400
17			Sareshkhauer	51	5	16,000
18			Wurgan Payan	39	4	12,800
19			Wurgan Bala	42	5	16,000
20			Pugish		20	64,000
21			Khandud	364	60	192,000
22			Sast	180	25	80,000
23			Sarkand	32	5	16,000
24			Kurt	110	16	51,200
25	Samangan	DarasufeBala	Dahan tur	186	17	54,400
26			Hosni burg	284	20	64,000
27			Hosni tagab	418	25	80,000
28			Kashka	160	16	51,200
29			Qazel bash	150	10	32,000
30			Said galagak	145	10	32,000
31	Ghor	Lal Sarjungle	Loka sang	77	12	38,400
32			Aab Qol	102	23	73,600
33			Sar-e-Boughondey	90	30	96,000

34			Shahi patab	81	7	22,400
35			Dahan sang khalil ulla	130	14	44,800
36			Safid Rig	220	15	48,000
37			Sar chahar Asyab	70	3	9,600
38			Dahan chahar asyb	146	10	32,000
39			Sang-e-Zard	250	24	76,800
40		Bamiyan centre	Zarsang	200	20	64,000
41			Baniyan Bazar	300	30	96,000
42			Dareali	300	25	80,000
43			Sher Dosh	60	5	16,000
44	Bamiyan		Sher Dosh	100	4	12,800
45		Yakwalang	Roqul Chahel Gow	70	7	22,400
46			Par Joyak (Dahan e Bom & Firoz Bam)	25	5	16,000
47	Kabul	Farza	Farza	200	20	64,000
48	Panjser	Rokha	Rokha	500	60	192,000
49	Takhar	Takhar	Taluqan	500	45	144,000
50	Balkh	Kishandee	Akoprok	1000	100	320,000
51			Seeyachob Mazar	600	25	80,000
52			Wakhashak	400	20	64,000
53		Khanjan	Khoob Dara	400	30	96,000
54	Baghlan	Dahana Ghori	Khaja Jaroo	200	8	25,600
	<b>Total</b>			<b>9,980</b>	<b>1,049</b>	<b>3,356,800</b>

**Annex 2 Detail Feasibility of Micro Hydro Power Projects**

S/N	Province	District	Project Name	Head	Flow	Installed Capacity kW	No of families	Status
1	Badakhshan	Zebak	Zer Khan	24	170	20	148	Under construction
2			Razrok	45	90	20	200	
3			Dashtukhan	12	325	20	224	
4			Farooq	8	300	12	50	Pending due to funding
5		Wakhan	Yamit	13	240	16	148	Under construction
6			Khandud	55	220	61	360	
7			Pagesh	19	220	21	157	
8			Qazi deh	12	600	36	300	
9			Sast	100	40	20	85	Design on going
10			Sakhawar	11	200	11	90	
11			Kurd	16	225	18	144	Pending due to funding unavailability
12			Ugayan Bala	15	80	6	50	
13			Urgayan Payen	18	90	8	60	
14			Iskashem	Gharan	60	60	18	112
15		Badardara		20	50	5	33	
16		Andaj		30	35	5	38	
17		Bazgeer		22	200	22	185	
18	Bamiyan	Yakwalang	Dareali	34	150	25	254	Under construction
19		Bamiyan Centre	Zarsang	14	250	18	210	
20	Samangan	Daresuf	Tahti Joy	5	800	20	400	Pending due to funding unavailability
21			Sayed Mir Akha	6.4	300	10	380	
22			Khol Charmaz	4.7	400	9	585	
23	Ghor	Lal Sarjungle	Loka sang	2.5	1000	13	77	Pending due to funding unavailability
24			Aab Qol	8	600	24	102	
25			Sar-e Boughonday	11	580	32	90	
26			Shahi patab	4.6	300	7	81	
27			Dahan sang khalil ulla	5	588	15	130	
28			Safid Rig	4.6	660	15	220	
29			Sar chahar Asyab	6	100	3	70	
30			Dahan chahar asyb	13.3	150	10	146	
31			Sang-e-Zard	5	1000	25	250	
32	Panjser	Rokha	Rokha	14	1000	70	500	Pending due to funding

	<b>Total</b>				<b>613</b>	<b>5879</b>	
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### Annex 3 Prefeasibility of Mini Hydro Power Project

No	Province	District	Village	No of families	Expected power output (kW)	Cost Estimate (USD)
1	Bamiyan	Yakwalang	Gazek	4000	600	3,000,000
2		Bamiyan Centre	Dokani	2000	250	1,250,000
3			Tupchi	3000	750	3,750,000
4	Badakshan	Khash	Khash	4300	400	2,000,000
5		Iskashim	Iskashim	500	100	500,000
			<b>Total</b>		<b>13800</b>	<b>2100</b>

## Annex 4 Status of ERDA Supported Micro Hydro Power Projects

S/N	Province	District	Project Name	Head (m)	Flow(lps)	Installed Capacity kW	No of families	Total project cost (US\$)	Status
1	Badakhshan	Zebak	Zer Khan	24	170	20	148	58,446	Canal rehabilitation being done
2			Razrok	45	90	20	200	50,792	
3			Dashtukhan	12	325	20	224	68,581	Tri partite agreement signed
4		Wakhan	Yamit	13	240	16	148	50,926	Canal excavation and stone collection completed. Announced in radio for electromechanica parts and quotation collected
5			Khandud	55	220	61	360	132,851	
6			Pagesh	19	220	21	157	72,347	Tri partite agreement signed
7			Qazi deh	12	600	36	300	109,052	
8	Bamiyan	Yakwalang	Dareali	34	150	25	254	72,285	80% rehabilitation of the canal completed
9		Bamiyan Centre	Zarsang	14	250	18	210	55,306	90% of the civil work completed. Company selected for hydro mechanical parts and 50% hydro-mechanical work completed
	<b>Total</b>					<b>236</b>	<b>2001</b>	<b>670,585</b>	

**Annex 5- Identification Study Format for Micro Hydro Power Projects****General**

1. Name of Scheme:.....

2. Location:

a) Village:

b) District:

c) Province:

3. Roadhead:

a) Name:  
Site: km

b) Type: Fair-weather/ All-round

c) Distance to

d) Walking Hours to Site: .....hrs (normal)  
(with load)

.....hrs

4. Name of Local Market (Bazaar):

***Technical Information***

1. Source:

2. Intake:

a) Location (X,Y)  
Elevation (Z):

b) Intake Type:

c)

3. Discharge:



5. Remarks:

Operation of Nearest MHP/ Turbine Mills

*Appendices & Attachments*

*List of People Met During Study*

	Name of Persons	Designation
1.		
2.		
3.		
4.		
5.		
6.		
7.		

Study Team Members

	Name	Designation
	Signature	
1.		
2.		
3.		
4.		

**Annex 6 : Feasibility Study format for Micro Hydro Power Projects**

***General***

3. Name of Scheme:.....

4. CDC ID Number:.....

5. Location:

a) Village:

b) District:

c) Province:

5. Roadhead:

a) Name:  
.....km

b) Type: Asphalt, Fair weather, Seasonal) Distance to Site:

d) Walking Hours to Site: .....hrs (normal) .....hrs  
(with load)

6. Name of Local Market (Bazaar):

***Technical Information***

3. Source:

4. Intake: Northing

Easting

Elevation

a) Location (X,Y)  
Elevation (Z):

b) Intake Type:

c)

## 10. Discharge:

a) Measured Flow River:                      lps                      b) River width:                      Survey date:

c) Methodology Applied:                      d) Minimum (Dry) Flow:                      lps (assessment through interaction with people)

d) Maximum Flow in Source (HFL or Flow):                      e) Status of water (clean, muddy, sandy)

f) Use of water:

Irrigation                      lps                      Water supply                      lps,                      Water Mill/Micro-hydro lps,

g) Amount of water available for proposed MHP:                      lps

## 11. Headrace Canal:

a) Type: New/ Existing                      b) Length:                      c) Alignment:

d) No of crossings                      e) Lined Section:                      m                      f)                      Unlined Section:                      m

g) Slope of canal                      h) Size for existing canal

12. Forebay/Desilting Basin location: North East  
Elevation

13. Location of Power House: Land Ownership: Private/ Government

14. Available Head (Gross): m

15. Penstock Length (approx): m No of bends:

16. Estimated Power Output: kW (50% overall system efficiency)

17. Location of control panel/fuse box in the power house

18. Tentative length of transmission line:

19. Distance from powerhouse to center of center of villages

20. Location of transformer

Remarks: (Comments on land use right, water use right, canal construction, location of natural spillways etc)

Diagram of System Layout of Scheme- Separately back side of this page

Electricity Use

1. Household Use (Lighting):

S.N.	Village	House Holds (HHs)	Average Subscribed Power Watt / HH	Total Subscribed Power in Ward kW	Remarks
1.					

2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
Total:					

2. Productive End-uses/ Enterprises:

S.N.	Possible End-use / Enterprises	Location	Required Power kW	Average Hours of Operation / day	Average Days of Operation / Month	Operational Months / Year	Total Power Used / Year	Remarks
1.								
2.								
3.								
4.								
5.								
6.								
7.								
Total:								

Grid Extension Possibility

6. Location of Nearest Grid Point:

7. Distance from Site to Grid Point: km

8. Plans of Grid Extension towards Site: Yes/ No

9. If Yes, Name of Village/ Location:

10. Remarks:

***Operation of Nearest MHP/ Turbine Mills***

S.N.	Name of MHP/ T. Mill	Location	Distance from Site	Capacity kW	Monthly Electricity Tariff	De-hulling	Grinding	Expelling	Others	Remarks
1.										
2.										
	Average Value:									

***Socio- Economic Information***

1. Public Facilities/ Institutions:

Public Facilities	Exist within Community Yes/ No	Distance from the Village Centre to the Facility, if Located Outside Community km	Remarks
Schools			
Health Posts			
CDC Office			
Post Office			
Bank			
Others specify if any			

Note: Explain about the physical condition, quality of services and relevant information in 'remarks'.

2. FPs and other NGOs involved in Socio-economic Development of the village:

FPs and other NGOs	Area of Support	Working Since	Remarks

### *Agricultural Production*

S.N.	Particulars	Annual Production		Remarks
		Unit	Amount	
1.	Rice			

2.	Maize			
3.	Wheet			
4.	Millet			
5.	Oilseed			
6.	Potatoes			

### Environmental Considerations

S.N.	Environment al Treats	Yes/ No	If Yes, Possible Recommended Measures	Remarks
1.				
2.				
3.				
4.				

### Local rates in the project area to calculate Project Cost

Description	Unit	Rate / unit	Comments
Sand			
Stone			
Coarse aggregates			
Wood			
Unskilled labour	Md		
Mason	Md		
Carpenter	Md		
Cement	Ba g		
Kerosene	L		

Diesel	L		
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***Proposed Operation & Management***

Particulars	Estimated Annual Cost (Afs )	Remarks
MH Plant Operator(s)		
MH Plant Manager		
Total Annual Cost:		

We, the undersigned certify that above information are correct and true. These information have been taken by the survey team in consultation with us.

	Name of Persons	Designation	Signature
8.			
9.			
10.			
11.			
12.			

Study Team Members

Name  
Signature

Designation

- 1.
- 2.

**Annex 7 : Technical Guidelines for Feasibility Study and Design of MHP Projects**

***TECHNICAL GUIDELINES FOR FEASIBILITY  
STUDY AND DESIGN***

***OF***

***MICRO-HYDROPOWER PROJECTS***

***DRAFT DOCUMENT***

***ENERGY FOR RURAL DEVELOPMENT IN AFGHANISTAN (ERDA)***

***NATIONAL AREA BASED DEVELOPMENT PROGRAM (NABDP) UNDP***

***MINISTRY OF RURAL AND REHABILITATION DEVELOPMENT (MRRD)***

***AFGHANISTAN***

## 1. BACKGROUND

In recent years, Afghanistan has witnessed a spate in installation of micro hydropower plants (MHP) for rural electrification. It is estimated that more than 1000 MHP have been installed in the country. However, the performances of these plants are mixed at best. It is believed that many of these plants are not generating electricity as envisaged while many others have become totally dysfunctional. Studies show that the problem starts right from site identification to survey, design, fabrication of equipment, installation, operation and management. The implementation modalities in practice do not provide adequate support to the communities to plan, install, operate and manage the system, there is very little oversight in the implementation process from the promoter.

The Ministry of Rural Rehabilitation and Development (MRRD) launched Energy for Rural Development Afghanistan (ERDA) with UNDP's support in 2008. ERDA is a component of a much larger National Area Based Development Program (NABDP) of MRRD. Among others, ERDA aims to demonstrate innovative methods of implementing MHP and other rural energy systems that suits the Afghan context. In this regard, ERDA is supporting the communities in several CDCs to install and manage MHP project.

This guideline is developed to conduct detail feasibility study of ERDA supported MHP projects. However, this could be used by other organizations and personnel involved in promotion of MHP in Afghanistan and elsewhere. This technical Guideline is not carved on stones and is just guideline for ERDA engineers to help the local communities. As the experience with implementation procedure accumulates, the guidelines will be updated or totally revised as per the need. This should be used in conjunction with ERDA implementation and NABDP's Operational Guidelines.

This technical guideline has borrowed heavily from Technical Guidelines of Rural Energy Development Program, Nepal which promoted community based rural energy systems. However, effort has been made to incorporate learnings from NSP Afghanistan to make them useful for the local context.

## 2. THE GUIDING PRINCIPLES

The Operational Guidelines of NABDP is based on certain principles that are equally applicable for ERDA. It is expected that the user(s) of this Guidelines will adhere to these principles in order to increase the efficacy and efficiency of their implementation works.

The principles are as follows socialisation, Simplicity, Community Empowerment, Accountability, Transparency, Adherence to Quality, Ownership and Stakeholders involvement.

## 3. MICRO HYDROPOWER PROJECT SELECTION CRITERION

Micro Hydropower is defined as those hydropower plants with the installed capacity of less than 100 kW.

### *3.1 Project Identification*

The basis of identifying micro hydropower projects for implementation is the District Development Plans (DDP). Projects might be identified by the communities (Community Development Councils or a cluster of councils, traditional organizations, government officials, non-governmental organizations (NGO) or individual entrepreneurs but have to be endorsed by the respective Community Development Council/s and District Development Authority and incorporated in DDP.

### *3.2 Pre and Detailed Feasibility Study*

ERDA will provide technical assistance to undertake pre-feasibility and detailed study of the projects. The pre-feasibility will consider the following factors to prioritize the potential MHP. The format for Pre-feasibility Study is attached in Annex

- i. **Geophysical Conditions:** There should be adequate flow in the river, adequate head at the site and stable terrain. Normally, a MHP is a run-off the river type scheme, so there will be no reservoir. The installed capacity of the plant is calculated on the basis of the minimum flow available all year around.. The site should be close to the load center and benefit maximum number of households.
- ii. **Distance from Electricity Grid:** The national electricity grid is unlikely to reach the proposed MH site within the next five years.
- iii. **Commitment of the community:** The community should be willing to provide voluntary labor for construction of the scheme, transportation of construction material and electromechanical equipment from nearest

road head as well as collection of locally available materials like sand, stone, aggregate and timber and contribute cash or take loan, if needed. The community has to contribute at least 10% of the total project cost. NABDP Operational Guidelines emphasizes on selecting beneficiary community based on the size (percentage) of their contribution to the total project cost.

Besides, each household should be willing to pay for consumption of electricity and the community should establish a Micro-hydro Operation Fund (MOF) to operate and maintain the plant once it is operational.

- iv. **Productive Use of Electricity:** There should be possibilities of using electricity for various productive-uses like enhancing agricultural production (e.g. lift irrigation), agro-processing (e.g. milling), electric cooking and off-farm enterprises (e.g. saw-mill, bakery, stone-crushing, etc.)
- v. **Multiple Use of Water:** In addition to producing electricity, there should be possibilities of using the water for other purposes, namely irrigation and drinking water.
- vi. **No other MHP:** To avoid duplication, there should be no other MHP in the CDC. If there is another MHP providing electricity to a small percentage of population, an Memorandum of Understanding clearly outlining the area of operation of each MHP has to be signed by all the parties including CDC and DDA involved.
- vii. **No Water Right Conflicts :** There should be no conflict on the water use right in the source stream/river. The community is solely responsible to resolve conflicts, if any, before implementation. The community has to provide an evidence in writing either from local Mirab (Water Headman) or DDA, in case there is no Mirab, stating their rights for water-use.

In this analysis, geophysical stability and absence of water rights conflicts are taken as preconditions. Geophysical stability ensures stable civil structures without incurring excessive costs. It has to be ensured that there is no water rights conflicts, or even if there is, it should be resolvable.

**Viii Security Situation:** Local security to implement the project is a precondition. ERDA will assess the security situation and only support projects in areas it finds secured enough. Besides, the CDC and DDA have to provide written assurance of providing security to all ERDA personnel, consultants and supplier/installer before a project is taken up for development. DDA also has to guarantee of safe access to all project personnel to and from the project site. If ERDA feels that the security situation is not good enough at any point in time it will withdraw all its personnel and halt its activities. However, if the project is in

advanced stage of development and works can be carried out without direct supervision of ERDA, implementation can proceed if the DDA takes total responsibility for technical backstopping and supervision.

### **3.3 Cost of ERDA Supported MH Schemes**

Based on the above mentioned criteria, potential schemes are screened for detailed study and further analysis. The projects thus identified are presented to the DDA for discussion and approval. Preference will be given to potential schemes whose per kilowatt non local cost is less than US\$ 3000.

## **4. TECHNICAL ASPECTS OF MICRO HYDROPOWER PROJECTS**

The ERDA emphasizes for the quality of works carried out and the services rendered to ensure the sound and reliable MH scheme. For this, a thorough exercise is carried out in the technical front in order to help enable to take appropriate measures for planning and construction leading towards the optimization of the overall quality and cost of the scheme. An intensive exercise with the beneficiaries following the participatory approach is extremely essential in the planning phase, which enables the technical team to assess the existing situation as well as take appropriate decisions regarding the design and implementation of the MH scheme.

It is expected that the use of these guidelines will result in a standard approach to designing and reporting on detailed feasibility studies of new isolated micro-hydro projects. The overall objective of these guidelines is that micro-hydropower plants become sustainable and thus their failure rates are minimized. The specific objectives are:

- Rural households are able to receive reliable and affordable electricity for household lighting, and other small enterprises and thus quality of life is improved
- Technically sound micro-hydropower projects are implemented.
- The plants are cost effective and financially viable so that external supports are not required for their operation and maintenance.
- Safety issues are adequately addressed.
- The plants promote some end uses based on available local resources, and market.
- Where feasible multi purpose projects that integrate hydropower with other uses of the water resources are promoted.

### **4.1 Civil Works**

The civil structures are used for the waterways of the scheme and are a major part of the project work. However, it is often assigned a reduced degree of importance and as a result, micro-hydro projects frequently suffer from waterway problems. Furthermore, it should be noted that the civil structures can not be completely standardized as there will always be site (topographical) variations. Thus, standard approaches are required to enable designs to deal with site-specific conditions. The ideal layout of the scheme depends on appropriate site selection for civil structures. A site that meets the following technical parameters is selected.

1. Simple and easy diversion works
2. Stable and natural intake
3. Short, stable and easy canal alignment
4. Natural way for diverting excess water
5. Normal and short penstock profile
6. Stable land for desilting basin, forebay and powerhouse.

Besides, the location of the power house is determined in view of the followings.

- Availability of sufficient head
- High flood level of river
- Distance from the load centres
- Availability of local construction materials

#### ***4.1.1 Diversion works***

The diversion works for a micro hydro power schemes control the flow of water from the source river into headrace. They comprise a diversion weir, an intake and sometimes river training works. The diversion works serve the following functions:

- Maintain the design flow with nominal headloss during both monsoon and dry season.
- Prevent or at least minimize the bed load and other floating materials entering the canal
- Safely contain peak flows in the river and away from the micro hydro systems so that damage is not caused to the structures.

The intake is one of the most sensitive parts of the MH scheme. A detailed investigation of the site is carried out by the technical team. Participatory rural appraisal is employed to get reliable information about river flow. This exercise is essential as the detailed scientific and measured hydrological and geological data of the location are not available in most of the cases. The weir and intake have to be simple but stable with minimum cost for

construction. Usually stone walls or gabion boxes are preferred for the weir whereas provision of simple orifice, sluice gates could also be provisioned at the intake to regulate flow. Some important factors to be considered while selecting and constructing the diversion weir and intake are as follows.

- ◆ The diversion weir is preferred to be made of local construction materials. (boulders, logs, gabions etc)
- ◆ The diversion structure shall be located at a relatively narrow section of the river to the extent that the hydraulic functions of the structural components do not interfere with each other.
- ◆ If a permanent weir has to be constructed, it should be safe from overturning and flash floods.
- ◆ The intake should be over sized for 5% to 10% of additional flows than the design flow so that seepage losses can be accommodated. Note that in case of multipurpose projects that need to accommodate additional flows for the secondary uses (e.g., irrigation flows need to be released from the intake), the intake should be sized accordingly.
- ◆ If possible it is suggested to locate intake by the side of rock outcrops or large boulders for stability and strength.
- ◆ If orifice is to be provisioned, it should be rectangular and submerged to pass through the full design flow.
- ◆ The discharge through an orifice for submerged condition is governed by continuity equation;

$$Q = A*V \text{ where } V = C \sqrt{(2g(h_r-h_h))}$$

Where

Q is the discharge through the orifice in m<sup>3</sup>/s

V is the velocity through the orifice

A is the area of orifice in m<sup>2</sup>

C is the coefficient of discharge of the orifice and dependent on the shape of orifice

G is the acceleration due to gravity = 9.81m/s<sup>2</sup>

$h_r$  is the water level in the river next to the orifice relative to a datum

$h_h$  is the water level in the headrace canal measured from the same datum as  $h_r$

- ◆ A coarse trashrack or simply steel bars should be fixed to prevent the entry of logs and boulders into the channel.
- ◆ In relatively big streams a sluice gate should be provisioned to regulate the flow.

- ◆ The structure should be designed and constructed to withstand maximum flood water.
- ◆ The river should be straight upstream and downstream of the intake.
- ◆ If needed to be selected at bends, the intake should be on the outer side of the bend to minimize the entering of sediments.
- ◆ The river should have gentle gradient at the site of intake.
- ◆ The river course should be permanent at the site of intake.

#### 4.1.2 Desilting Basin

The water drawn from the river carries a suspension of small particles of solid matter which is in most cases composed of abrasive materials like sand. To remove these sand particles, a suitable silt basin has to be built at the channel entry. The forebay tank works as the final desilting tank. While selecting the site and constructing the silt basins, following important principles are recommended.

- ◆ The dimensions of the basin should be large enough to settle the suspended particles. However, their size could be optimized by increasing the emptying frequency.
- ◆ It is sufficient to remove particles bigger than 0.3 mm in diameter that have nominal velocities of more than 0.03m/sec.
- ◆ Width of the settling basin ( $W_{\text{settling}}$ ) should be 5-15 times the width of the canal section
- ◆ The straight length to width ratio (i.e., aspect ratio) of the settling zone should be within the range of 4 to 10. Longitudinal divide wall may be incorporated to improve the aspect ratio.
- ◆ The storage volume of the basin should be adequate for a flushing frequency of twice a day, when sediment loads are high in the river, i.e., 12 hours of sediment storage capacity.
- ◆ Minimum depth of the settling basin ( $D_{\text{settling}}$ ) should be more than depth of the channel ( $D_{\text{channel}}$ )
- ◆ Full depth of basin =  $D_{\text{channel}} + D_{\text{collection}}$
- ◆ Length of Entry ( $L_{\text{entry}}$ ) = Length of Exit ( $L_{\text{exit}}$ ) = Width of Setting Basin ( $W_{\text{settling}}$ )
- ◆ The Vertical Sinking Velocity of Particles ( $V_{\text{verticals}}$ ) = 0.03 m/s (for 0.3 mm 0 particles)

$$Q \text{ (m}^3\text{/sec)}$$

$$\text{◆ Length of Basin (} L_{\text{settling}} \text{)} = \frac{Q \text{ (m}^3\text{/sec)}}{W_{\text{settling}} \times V_{\text{vertical}}} \text{ meter}$$

$$\text{Silt load (kg)} = Q \times T \times C$$

- ◆ Where
  - ◆ Q is the design discharge  $\text{m}^3\text{/s}$
  - ◆ T is the emptying frequency in S

◆ C is the sediment concentration in kg/m<sup>3</sup>

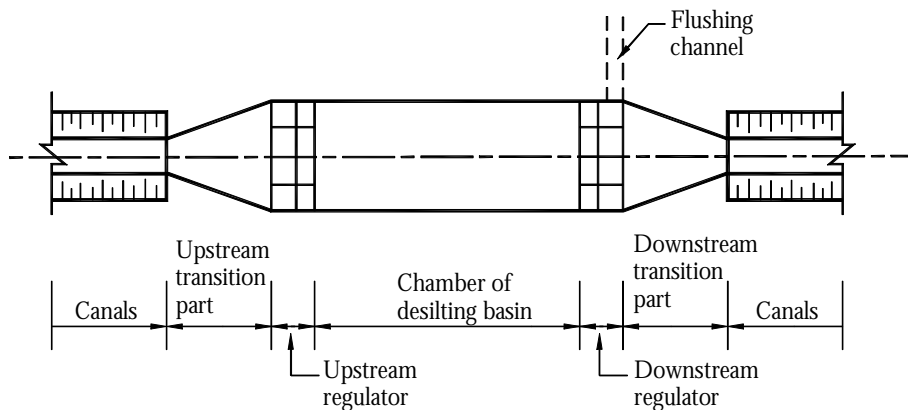
$$\text{Volume of sediment (V}_{\text{sediment}}) = \frac{\text{Silt Load (Sload in KG)}}{\text{Sdensity} \times \text{Pfactor}}$$

Density of sand = 2600 kg/m<sup>3</sup>, Assume a packing density of 50%

Tank capacity (m<sup>3</sup>) is decided based on volume of sediment to be stored.

◆ Depth of the Collection Tank (D<sub>collection</sub>) =  $\frac{\text{Tank Capacity (m}^3\text{)}}{\text{W}_{\text{settling}} \times \text{L}_{\text{settling}}}$  meter

- ◆ Check that the horizontal velocity (V=Q/Bxy) is less than 0.44√d<sub>limit</sub> i.e V<0.24m/s
- ◆ The structure should allow easy flushing and the water removed from the flushing exit must be led away carefully avoiding the soil erosion.
- ◆ The basin should avoid flow separation and turbulence caused by sharp area changes and bends.
- ◆ The structure should be closed to the intake structure as far as possible which facilitates the short route for the flushed water into the stream, besides avoiding high velocity in canal to carry the suspended particles upto the basin.



### 4.1.3 Headrace Canal

The canal is one of the most critical components of a MH scheme. The reliability of operation as well as the cost of the scheme largely depends upon the type, length, size and the condition of the canal. Hence, a thorough exercise is carried out before fixing the appropriate canal alignment. It is chosen in such a way that the construction could be done without much difficulties with simple structures. Landslides and fragile geological zones are always avoided as far as possible. The canal is made as short as possible so that chances for cross-drainage works would be

minimized. Lining of canal is recommended with stone masonry works or other locally available construction materials in necessary places. The farmers managed irrigation canal is preferred where minor improvements would be sufficient for the assured conveyance of water not only for power generation but also for the irrigation purpose. While planning the scheme, the prospects of the multiple use of the water will always be taken into consideration, which would ensure the use of tailrace and overflow (spill-over) water for irrigation. Lined canal sections are optimized through proper canal gradient. Use of locally available construction materials and the local labor is a prerequisite. It must have the minimum possible material cost, construction cost and maintenance cost. HDPE pipes are also used for conveyance in appropriate places. For optimum canal design and construction, the following principles are kept in mind.

- ◆ The velocity of water should not be less than 0.3 m/s to avoid silt deposition or growth of weeds, however excessive velocity should also be avoided to check soil erosion.
- ◆ There should be minimum cross drainage works in the canal alignment.
- ◆ Adequate spillways should be provisioned, especially by using natural gullies to maintain the desired flow in the canal.
- ◆ Canals should be in 'cut' in all places as far as possible and berms should be provided in deep cuts.
- ◆ A freeboard of min. 30 cm. should be allowed in the canal section.
- ◆ The hydraulic principles of open channel flow are based on steady state uniform flow conditions. The most commonly used and widely accepted approach for the discharge calculation in open channel is Manning's equation.

$$V = \frac{1}{n} \times R^{\frac{2}{3}} \times S^{\frac{1}{2}}$$

Where,

- V = Mean velocity, in meters per second
- n = Manning's coefficient of roughness of the channel material which is based on materials and workmanship required.
- S = Channel slope, in meters per meter
- R = Hydraulic radius, in meters = A/P
- A = Cross sectional flow area, in square meters
- P = Wetted perimeter, in meters

The best form of cross-section of a canal is a section which is practical in construction and gives maximum discharge for a minimum cross-sectional area for a given bed slope.

Normally rectangular and trapezoidal sections and corresponding formulae is given below.

Formula/Shape	Rectangular	Trapezoidal with Side Slope z
Area (A)	$b * h$	$(b + zh)h$
Wetter erimeter(P)	$b+2h$	$b + 2h\sqrt{1 + z^2}$
Hydraulic adius (R)	$\frac{bh}{b + 2h}$	$\frac{(b + zh)h}{b + 2h\sqrt{1 + z^2}}$
Water Depth (D)	$h$	$\frac{(b + zh)h}{b + 2zh}$

Typical Manning's Roughness Coefficients for Channels

Channel Material or Type	Manning's n
Clean, straight earthen channel	0.022
Concrete-lined channels	0.013 - 0.017
Asphalt-lined channels	0.013 - 0.016
Riprap-lined channel	0.030
Channel with cement plaster	0.011
Brick work	0.014
Rock cut channel	0.035 - 0.040
Channel with gravel	0.022 - 0.030
Older wooden channel	0.015
Natural river bed	0.024 – 0.05

#### 4.1.4 Spillway

In order to control access water in the canal, provision of spillway is made in the desilting basin. Escapes are also positioned in suitable places along the power canal for the purpose. Provision of these spillways or escapes are suggested in such places where natural 'water way', or hard rocks do exist, so that much construction works are not required. Provision of spillways in appropriate locations along the power canal would facilitate the flow of only the desired discharge.

$$Q_{\text{spillway}} = C_w \times L_{\text{spillway}} \times (h_{\text{vertop}})^{\frac{3}{2}}$$

Where

$Q_{\text{spillway}}$  = Discharge over the spillway in m<sup>3</sup>/s

$L_{\text{spillway}}$  = Length of the spillway in m

$H_{\text{vertop}}$  = head over the spillway in m (height of water over the spillway)

$C_w$  = a coefficient (similar to weir coefficient, 1.6 for broad crested weir)

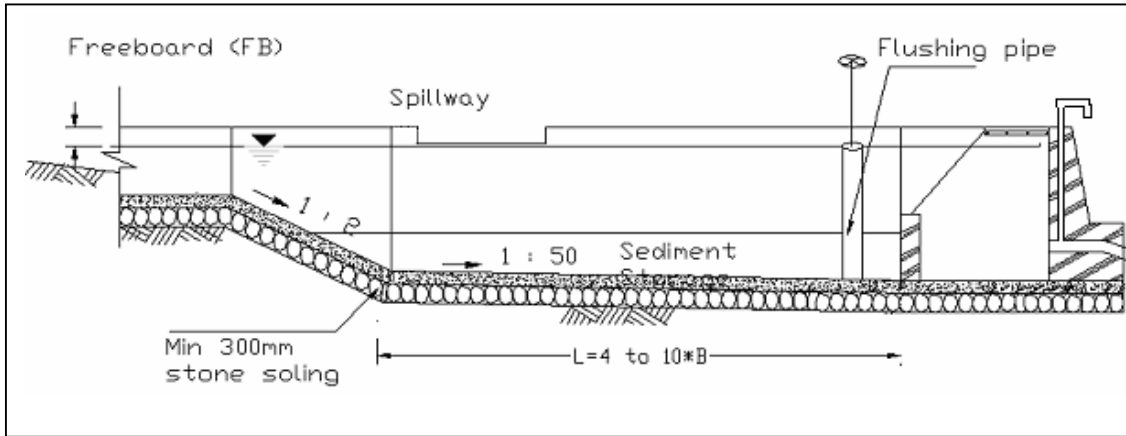
### **4.1.5 Forebay**

While constructing a forebay tank, it is noted that the penstock pipe is fully submerged to limit vortices in the forebay water. An air vent is placed at the point where the penstock is joined to the forebay tank so as to check the inward collapse of the penstock in case the penstock mouth is blocked for some reasons. Provision is made to divert the entire flow from forebay without causing any damage to the structures (canal, power house) already built. The length and width of the forebay should be sufficient enough ( $L_{\text{settling}} - 4$  to 10 width) for settling suspended silt particles of all sizes greater than 0.3 mm. The shape of the tank should be such that it should not make the flow turbulent. A simple flush system to flush out sediments safely back to the stream or onto an agreed location is provisioned. A fine trashrack is also incorporated, especially to check the floating objects. In case of pelton turbine, the bar space of the trashrack should not be more than half the nozzle diameter. If spare valve is used, it should be a quarter of the nozzle diameter.

As far as practicable, the size of the forebay should be such that the active volume above the penstock pipe is adequate to store 15 seconds of design flow without spilling.

A 300 mm free board above the design water level should be provided.

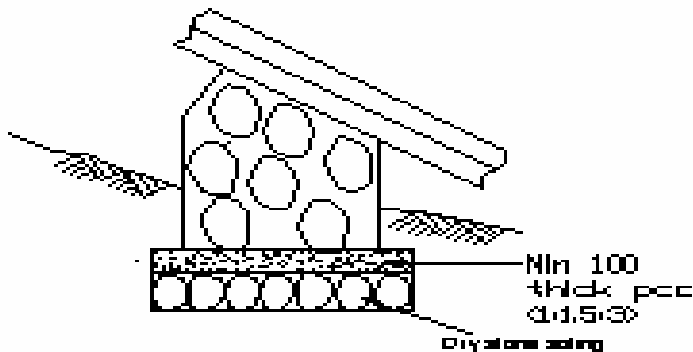
Design principle for forebay is same as the desilting basin mentioned above.



#### 4.1.6 Support Piers

Support piers carry the weight of pipe and water. They restrain the pipe from upward and lateral movement but allow the pipe for longitudinal movement. Support piers also stop the pipes from pulling apart due to the upward or lateral movements caused by the pressurization inside them. Some basic points to be noted are as follows.

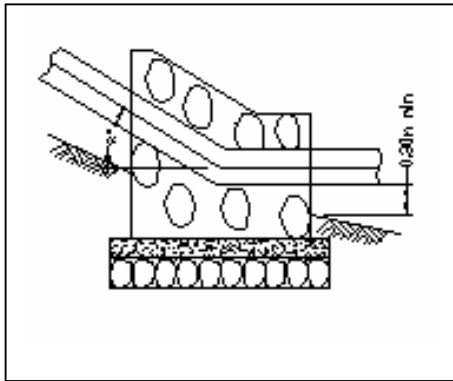
- ◆ Support piers should withstand overturning and sliding effects.
- ◆ In order to minimize the friction effect on the penstock pipe, a metal plate is recommended to be placed on top of the support pier. Durable tarpaulin sheet may be used instead of a metal plate.
- ◆ Provision of 'C' clamps would be good solutions to prevent vertical and side movements of penstock pipes.
- ◆ For flexible coupling of steel penstock pipes, one support per length is recommended in normal situations.
- ◆ In case of PVC and HDPE pipes, the manufacturer's recommendations should be followed.



### 4.1.7 Anchor Blocks

Anchor blocks are mostly made of concrete with necessary reinforcement. They are keyed to the penstock so that the latter cannot move in any direction. Anchor blocks are placed in the following places.

- ◆ At the point at which the penstock enters the power house and immediately after forebay.
- ◆ At every vertical or horizontal bend in the penstock.
- ◆ At every 30 m of straight sections of penstock.
- ◆ Apply thumb rule of 1 cubic meter of concrete for every 300mm diameter of pipe for smaller schemes (below 20kW and 60m head)
- ◆ For bigger schemes, a full analysis is needed



Anchor blocks are designed against overturning and sliding. Concrete of 1:3:6 mix. (cement, fine aggregate and coarse aggregate) with 40% plum are recommended. For larger schemes and in specific cases, a full analysis is carried out taking into account all the forces that act upon them.

### 4.1.8 Power House

The site for the construction of power house should be stable enough for the installation of electro-mechanical equipment. Also the area should be large enough for housing the equipment as well as easy access for operation and maintenance works. The design of the power house is suggested to be made simple so that the community members could construct it using locally available construction materials to the maximum extent. However, the

requirements and the technical aspects should be duly taken into account. Usually the walls are made of stone masonry in cement sand mortar. The structure should be water proof. The floor is recommended to be made of concrete, the inside walls to be cement-plastered and outside walls pointed or plastered by rich cement mortar. If possible, the operators' quarter are suggested to be built attached to the power house in order to save the housing cost. The minimum floor area inside of the power house should be 10 sq. meter. The inside area of the power house with other endues like milling equipment should not be less than 12 sq. meter. The space for operator's quarter if attached to the power house is recommended to have at least 7 sq. m.

In most cases the power house is located near to the parent river or some natural water way so that excess water in the forebay could be diverted towards these.

#### ***4.1.9 Tailrace***

Based on the topography, either an open canal or a pipe should be used for tailrace. The design considerations for the tailrace should be similar to the headrace although the ground profile can be steeper. The tailrace should be able to divert the flows from the turbines to the river (or nearby gully) without undermining the powerhouse foundation or the hill slope and the riverbank. The tail race canal should be higher than the flood level.

### ***4.2 Mechanical Components***

Mechanical components such as trashrack, penstock pipe, turbine and speed transmission systems are the main components of a MH scheme. The selection of appropriate type, size and materials of mechanical component has a significant effects on the power generation and durability of the scheme. Some basic guidelines for the selection of these components are described below.

#### ***4.2.1 Trash Rack***

Trash racks are placed at the intake to protect logs and other large waterborne objects from entering the canal, and at the forebay to protect leaves, twigs and small floating objects from entering the penstock. The following points are taken into consideration while selecting and fixing a trash rack.

- ◆ For intake a course trash rack, usually of mild steel bars and or rectangular section for bracing and frame should be provided.

- ◆ For forebay, a fine trash rack should be provisioned. For pelton turbines, the design of trash rack should be quite precise.
- ◆ Trash rack design area,  

$$A_{dt} = Q/0.2 \text{ m}^2$$

where,  $A_{dt}$  = design area of trash rack (sq. m.)

$Q$  = design flow, Cu. m./sec.

0.2 = the velocity through trash rack in m/s

- ◆ Each section of the trash rack shall not be more than 45 kg for ease in transportation.
- ◆ The inclination angle of the trash rack should be between 60° – 80°.

#### ***4.2.2 Penstock Pipe***

The penstock pipes convey water from the forebay to the turbine under pressure. Mild steel penstock pipes are widely used for penstocks.

The mild steel penstock pipes are relatively heavy, but they can be manufactured in appropriate sections for ease in transportation as well as installation. The basic design principles are suggested below.

Diameter of Penstock Pipe,

$$D = 41 \times Q^{0.38}$$

where,  $D$  = internal diameter of pipe in mm

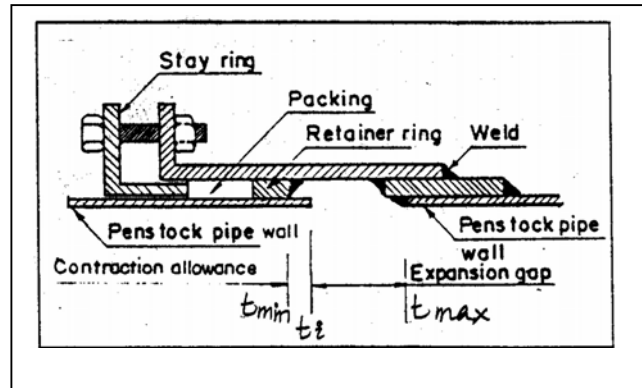
$Q$  = design flow in LPS

- ◆ Diameter of penstock pipe should be selected the nearest rounded up standard pipe diameter from manufacturer's tables on the upper side.
- ◆ Total head loss in the penstock pipe should not be more than 5% of the operating head.
- ◆ Velocity of water flow in the penstock should not be more than 3 m/s.
- ◆ If mild steel penstock pipe needs to be buried, a 1 m burial depth should be maintained and corrosion protection measures such as high quality bituminous paints should be applied. Due to higher risks of leakage, flange connected penstocks should not be placed underground.
- ◆ While selecting the wall thickness of penstock pipes, take Safety Factor (SF) =3. However, it could be taken 2, if the following considerations are made.
  - The head is low and the slope is mild. (effect of burst is not very much likely)
  - Slow closing valves are used.

- Assembly and welding of the penstock pipes are carried out by experienced technician as per standards.
- The penstock pipes are pressure tested in lab before the use in site.

### 4.2.3 Expansion Joints

During heating and cooling, the penstock pipes are subjected to forces of expansion and contraction. In order to compensate for the maximum possible change in length, expansion joints are essential. Expansion joints are necessary to be placed just below the forebay and just below every anchor block. Attention should be paid during installation. If the expansion joint is to be fixed in the cold weather, adjustment of the length is necessary, so that the pipes could expand during hot season, and vice versa.



The expansion joint is to be fixed in the cold weather, adjustment of the length is necessary, so that the pipes could expand during hot season, and vice versa.

The expansion of the pipeline can be calculated as follows:

$$\Delta L = a \times \Delta T \times L$$

Where,

$$L = \text{Length of the pipe section, (m)}$$

$$\Delta L = \text{Change in length due to expansion (m)}$$

$$a = \text{Coefficient of linear expansion of steel}$$

$$= 12 \times 10^{-6} \text{ m/m } ^\circ\text{C}$$

$$\Delta T = \text{Change in temperature (} ^\circ\text{C)}$$

To be safe, it would be recommended that the expansion joint can be capable of accommodating a length change of double this amount.

### 4.2.4 Oscillation Valves

Oscillation valves are used to shut down the plant. It is very advantageous to place a valve at the entry to the turbine, to ease uncoupling of the turbine with the penstock. An air vent should be placed downstream of the penstock inlet to avoid vacuum collapse of the penstock at the time of emptying or at the time when the penstock mouth is closed accidentally. For MH schemes, butterfly valves are the most common ones. As far as possible, minimum number of valves should be used. Flow control valves are built in

turbine and are required to regulate and control the flow. The following points should be taken into account about the uses of valves.

- ◆ An air vent should be installed downstream of the penstock inlet.
- ◆ A butterfly valve (gear operated) is most appropriate one for the stop valve.
- ◆ Spare valves should be used to regulate the flow to a pelton turbine. Spear valves should never be used to stop water flow.
- ◆ Valves made from bronze or brass are recommended for the use.

### 4.2.5 Turbine

A turbine converts energy of falling water into rotating shaft power. The selection of an appropriate turbine depends on the configuration of the site. There are different types of turbines. The crossflow turbines are the most commonly used in Afghanistan. The selection of the right type of turbine is suggested by the use of nomogram following the steps as mentioned below.

- ◆ Turbine Output Power  $P = e_{\text{turbine}} \times Q \times g \times h$     kW  
 where,  $e_{\text{turbine}} = 65\%$  for crossflow,  $75\%$  for pelton

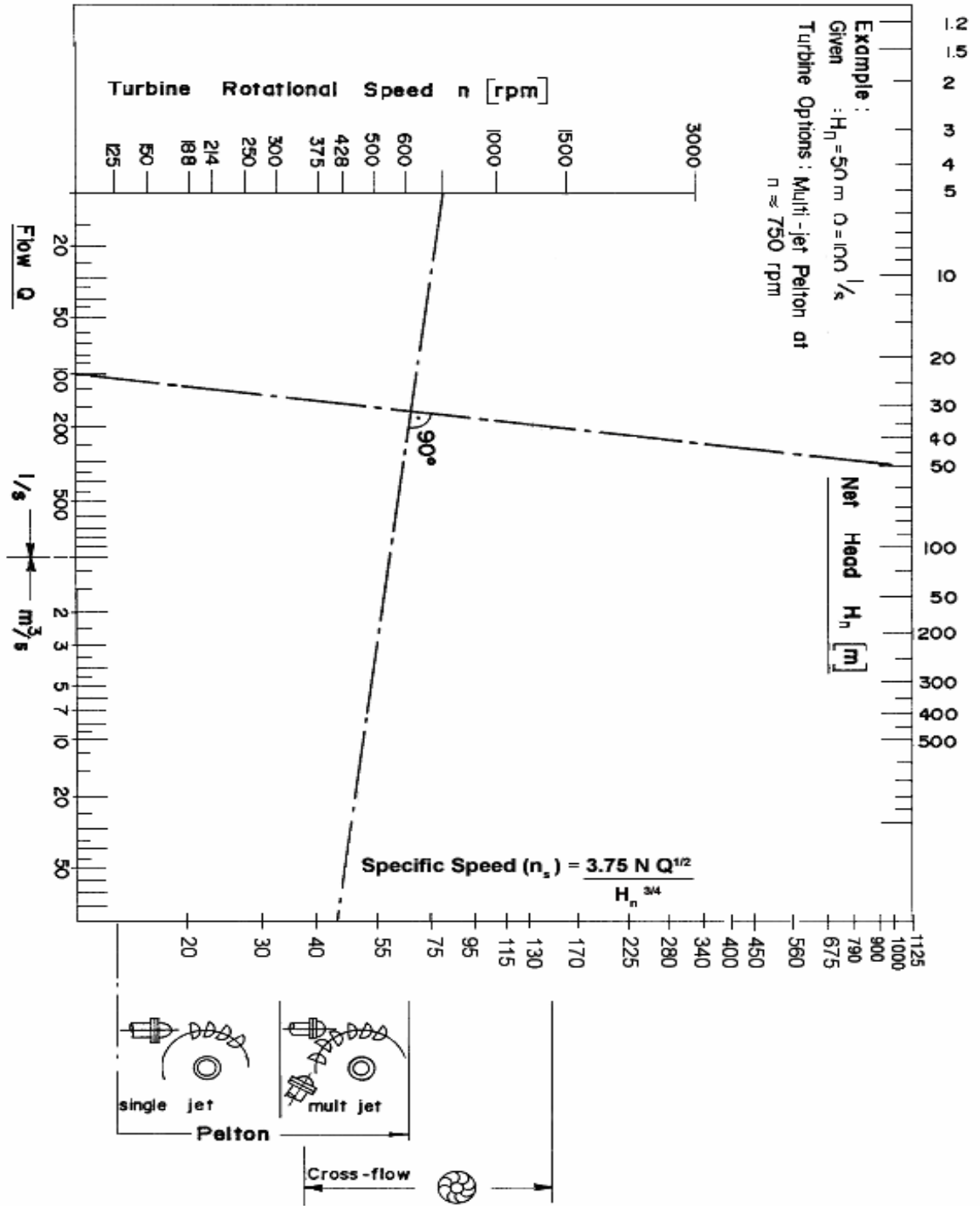
$Q$     = design flow in Cu.m./sec

$g$     = acceleration due to gravity,  $9.81 \text{ m/s}^2$

$h$     = head in meter

- ◆ Mark the head (m), turbine shaft speed (RPM) and turbine output (shaft) power (kW) on the nomogram.
- ◆ Draw a straight line connecting the design flow and the head.
- ◆ Speed up ratio should not be more than 3.
  - For 1500-RPM generator, turbine shaft speed should be in the range of 500- 1500 RPM
  - For direct coupling, the turbine shaft coupling should be set at 1500 RPM
- ◆ Select the desired turbine shaft speed (RPM) and draw a line from this point (RPM) at right angle to the previous line. Project the line to the top boundary of the nomogram.
- ◆ Select the right type of turbine.

Turbine Selection Nomogram



(For detail design and size selection of turbines, please refer to MH Design Manual – Adam Harvey)

#### **4.2.6 Drive System**

The drive system is comprised of the generator shaft, turbine shaft, bearings, couplings, pulleys, belts and other components used to change the speed or orientation of the drive. The function of the drive system is to transmit power from the turbine to the generator shaft in a required direction and at a required speed. The following considerations should be made for the selection of a drive system.

- ◆ Direct coupling is appropriate when the RPM of both the generator and the turbine are the same.
- ◆ If the speed of the generator and turbine are different, belt drives should be used.
- ◆ The power to be transmitted (required power of drive) is :

$$P_{\text{trans}} = \text{Output power of generator} / \text{efficiency of generator}$$

$$= P_{\text{outgen}} / e_{\text{gen}} \text{ kW}$$

- ◆ Minimum centre distance between turbine pulley and alternator pulley (Distance):  
Distance = Diameter of larger pulley + Diameter of smaller pulley
- ◆ Use of V belts is recommended for schemes of power output less than 20 kW.
- ◆ Manufacturer's catalogue should be used when designing a belt drive. (For more details, please, refer MH Design Manual-Adam Harvey)

### **4.3 Electrical Components**

Electrical components are the very sensitive parts of a MH plant. They consist of the generator, control system, transmission system, distribution system, earthing, power limiting devices, etc. Electrical design should be carried out carefully to have optimum power output as well as reliable operation of the system.

#### **4.3.1 Generator**

Two types of generators are available: synchronous and asynchronous (induction). Induction generators are inexpensive and appropriate for smaller schemes. For larger schemes, synchronous generators are recommended, because induction generators have problems supplying large inductive

loads like starting of asynchronous motors. Both types of generators are available in single and three phase.

Generally asynchronous (induction) generators are cheaper and simpler than the synchronous ones, but they are not good for supplying powers to run motors, as they cannot supply reactive powers. So, if the MH plant is required to supply powers to the motors, a synchronous generator should be selected.

#### Selection of Generator

	Size of Scheme		
	Upto 10 kW	10 to 25 kW	> 25 kW
Type of Generator	Induction or Synchronous	Synchronous or Induction	Synchronous
Phase	Single or Three Phase (depending on load)	Three Phase	Three Phase

Factors affecting the size of generator are temperature, altitude, Electronic Load Controller (ELC) correction factor and power factor of the load. Derating coefficients for the above mentioned factors are presented below.

#### Generator Rating Factors

	Max. ambient temperature in °C	20	25	30	35	40	45	50	55
A	Temperature Factor	1.1	1.08	1.06	1.03	1.00	0.96	0.92	0.88
	Altitude	1000	1500	2000	2500	3000	3500	4000	4500
B	Altitude Factor	1.00	0.96	0.93	0.90	0.86	0.83	0.80	0.77
C	ELC Correction Factor								0.83

D	Power Factor	When load is light bulbs only	1.0
		When load includes tube light and other inductive loads	0.8

Selection Steps

- ◆ Power factor is determined by load. Usually, 0.8 is taken.
- ◆ Determine the value of controller correction factor, altitude and temperature factor from the Table.
- ◆ The size of the generator should be calculated by using the formula below.

Power Output (kW)

Generator KVA = -----

A x B x C x D

- ◆ Add a safety factor of 25-30% to allow for excess output from the turbine than the design output and to handle the starting current of the large motors (10% of generator size).
- ◆ To minimize the maintenance cost, use of brush-less generators are recommended for the projects bigger than 20kW .
- ◆ The generator must have AVR that can regulate the voltage + - 5% from no load to full load.

**4.3.2 Electronic Load Controller (ELC) / Induction Generator Controller (IGC)**

The ELC is a device that maintains a constant electronic load on a generator in spite of the change of user loads. This permits the use of a turbine without flow regulating devices and the governor control system. The flow through the turbine is set at a constant amount and the load controller ensures that a constant electrical load is supplied by the generator. As the turbine power output is constant, the speed is also constant. The load controller maintains a

constant generator output by supplying a secondary ballast load with the power that is not required by the main load.

Recent works on the use of induction generators in place of the normally used synchronous generators have led to the development of induction generator controllers. This is designed specifically, for use with induction generators and combines the function of both the load controller and the automatic voltage regulator. It thus controls the speed of a turbine/induction generator set in a similar way to an ELC.

### ***4.3.3 Control System in the Power House***

A good workmanship should be maintained while carrying out the electrical installation in the power house. The following points should be taken into account while carrying out the electrical installation in the power house.

- ◆ Only copper cables should be used in the power house to ensure good connections.
- ◆ Cables connecting various equipment should be double insulated for additional protection. Single insulated cables could be used if inserted in pipe or conduit.
- ◆ Multi strand cable should be used for connection to the generator because of vibration.
- ◆ In order to protect cables from sharp edges cable glances should be used.
- ◆ All connections in both control and main circuits should be re-checked by pulling each wire with pliers and checking the tension of screws after the completion of the assembly of the cables.
- ◆ All wires should be neatly attached to structural parts to save them from accidental pullout.
- ◆ All the electrical installation should be protected from water and mice damage.
- ◆ If aluminum cable is used between the main switch and outside poles or transformers, cable shoes or reducer sockets should be used at the main switch, as this is usually a weak point.
- ◆ The size of neutral conductor from generator to IGC/ELC should be equal to that of line conductors, as the ELC introduces high neutral currents.
- ◆ Cable shoes should be used at connection points in the power house.
- ◆ Cables should be oversized by around 50 % in the power house.
- ◆ For protection of the village load main switch, a HRC (High Rupture Current) fuse should be installed.
- ◆ The main switch should be overrated by about 25 %.
- ◆ The neutral line should not have a fuse.
- ◆ Provision of monitoring devices should be made for the main current, generator voltage, frequency and ballast voltage.

- ◆ Devices to protect against over/ under voltage and over /under frequency should be installed on all plants which are larger than 10 kW.
- ◆ Overload protection should be provided on all plants.
- ◆ The ballast heater rating should be 20% higher than the plant capacity.
- ◆ Water heaters are recommended for use as ballast load, as they require less maintenance.
- ◆ A control diagram of the panel board should be kept in the power house.
- ◆ The generator controller should regulate the frequency within +- 5%.

#### ***4.3.4 Earthing***

Earthing should be done as per technical specifications. However, following points are suggested to take into considerations during the works.

- ◆ The resistance to ground should not be more than 50  $\Omega$  for all plants. 5  $\Omega$  is preferred and the smaller the value, the lesser the chance of damage from lightning.
- ◆ The generator neutral should be earthed.
- ◆ All metal casings and guards should be earthed. (equipment earthing).
- ◆ There should be two different earth pits outside the power house for neutral, equipment and lightning arrestor.
- ◆ Brass or copper connections should be used for earthing.
- ◆ Earth electrodes should be copper plates having dimensions 600 mm x 600 mm x 3mm (thickness).
- ◆ The copper earthing plate should be buried in a trench of minimum 2.5 m depth.
- ◆ The first meter of covering of the earthing plate should be fine clay mixed with layers of charcoal and salt.
- ◆ The best place for earthing is a location with moist fine soil (clay).
- ◆ Earth wire should be of standard wire available in market.
- ◆ Exposed sections of the earth wire should be inserted in GI pipe to protect them from theft.
- ◆ Lightning arrestors which have been installed at every kilometer of transmission / distribution line and more in lightning prone zones, should be earthed.

#### ***4.3.5 Transmission System***

Transmission lines can either be buried or suspended overhead. Overhead lines are more common as they are less expensive and easier to install. Overhead lines are also easy to repair and maintain. In areas, where houses

are densely located or heavy snowfall is expected during winter, underground transmission lines are recommended, though it would be more expensive. The design of transmission and distribution line should be such that the maximum voltage drop should not be more than 10%. ACSR conductors are generally used for overhead transmission lines in MHP schemes. These are available in various sizes and specifications. If the transmission system is underground, PVC insulated armoured cables should be used.

Conductor spacing on the poles should be at least 300mm in low and medium tension (up to 1 kV). In vertical alignment, the neutral should always be the lowest. Clearance to conductors from the ground should be at least as presented in the following table.

Minimum clearance to overhead conductors

Places	Low Tension	High Tension (1-11kV)
Over open ground	4.5 m	5 m
Beside motorable road	5.5 m	6.0 m
Across motorable road	6.0 m	6.5 m

The minimum sag for cables up to 11 kV can be calculated by:

$$d = (L/ 172.8)^2$$

where d = sag in metres

L = span in meter

Sag of overhead cables

Span in m	20	30	40	50	60
Minimum sag in mm	13	30	54	84	121

Transmission poles should be of hardwood, RCC or galvanized steel. There are standard sizes of RCC and steel poles available in the market. For the use of wooden poles appropriate dimensions are given below.

#### Specification for hardwood pole

Minimum Length (m)	6.5	7.0	8.0
Maximum Span (m)	35	35	40
Buried Length (m)	1.0	1.2	1.5
Min. top diameter (mm)	120	125	140
Min ground clearance (m)	4.5	4.8	5.5

Where hardwoods are not available, necessary treatment should be carried out.

Shackle insulators should be used in low voltage distribution lines for dead ending and supporting conductors that are laid vertically. Insulator dimensions and appropriate conductors are presented in the table below.

#### Specification of insulators

Size	Dimension	Weight	Used in Conductor
Small	55mm x 55 mm	200 gm	Less than 16 mm <sup>2</sup>
Medium	75 mm x 90 mm	600 gm	25 mm <sup>2</sup> to 50 mm <sup>2</sup>
Large	100 mm x 110 mm	1300 gm	More than 72mm <sup>2</sup>

Pin, disc, strain and post insulators are used for high voltage transmission. The voltage and span determine the minimum spacing of the conductors. A spacing of 25-30 cm is sufficient for low-tension lines in vertical alignment. For aluminum conductors in horizontal or triangular alignment, spacing is determined by:

$$\text{Spacing (m)} = (d + V/150)^{1/2}$$

where, V = Voltage in kV

d = Sag in meters

Generally 70 % is added as a safety factor for the above calculated value.

Provision of stay sets should be made at the first pole, the last pole and at all bends. Generally, for safety, every fifth pole is stayed on both sides even if the poles are in a straight line. This provides protection from storms. Transmission lines should be tried to make shortest possible in order to minimize the poles as well as the conductors..

#### ***4.3.6 Line Distribution to Houses***

The following points should be taken into consideration while distributing the lines to the houses.

- ◆ Service wire should be double insulated.
- ◆ Service wire should be of the same material as the line conductor (aluminum) to avoid galvanic corrosion.
- ◆ For mechanical strength, wire of at least 4 mm<sup>2</sup> must be used as service wire for lighting loads.
- ◆ Service wire should be connected tightly to the line conductor (tight 10 turns of service wire on line conductor).
- ◆ Automatic switch based on subscribed power should be installed at each house.
- ◆ The fuse of the main switch should be rated to protect against exceeding the maximum current rating of service and house wiring.
- ◆ To avoid overload of the plant, load limiting devices (ECC, PTC, MCB) should be installed at every household.
- ◆ For easy maintenance and fault finding, the distribution system should be divided into groups separated by switches and fuses. Switches should be protected from water.
- ◆ Service wires should be tied to poles to avoid tension in connections.

#### ***4.3.7 House Wiring***

It is of utmost importance to pay attention to the house wiring works as electrical accidents are most likely to occur inside houses. If well done at the outset, it will last for years. If all houses need to be wired at the same time and many houses need the same system, (e.g. two lights, two sockets) it could be a quick and safe alternative to use readymade wiring. For this purpose, the complete system of house wiring could be assembled beforehand and the wiring system could be just hung up in the house. Some useful notes regarding house wiring are as follows.

- ◆ Make sure that all the wiring work is firmly connected to house structures, so that it is not pulled off by accident.

- ◆ All the connections should be made inside connection boxes. A connection simply covered by tape does not offer a long lasting solution and must not be seen outside the connection boxes.
- ◆ All installations should be protected against damage from water.
- ◆ If the house is protected by an earth fault relay, it will improve safety to a great extent. To cut the cost, the relay could be located centrally for protection of a group of houses.
- ◆ Except in the switch fuse unit (main switch), there should not be any fuses on the neutral conductor.

#### ***4.3.8 Drawings and Documentation***

The designed parameters should be depicted in drawings to the maximum extent possible. The important sections should be presented separately, preferably in large scale (1:50, 1:20). The minimum drawings and documentation that are required for a MH scheme are as follows.

##### ***Drawings***

- ◆ General layout plan (system layout) (not to scale)
- ◆ Diversion works and intake
- ◆ Profile and sections of canal (headrace, tailrace, overflow)
- ◆ Structures in the canal
- ◆ Desilting basin
- ◆ Forebay tank
- ◆ Overflow, spillways
- ◆ Land profile for penstock laying
- ◆ Anchor blocks and support piers
- ◆ Power house building (including location of equipment)
  - ◆ Main Circuit Diagram
  - ◆ All connecting points between equipment
  - ◆ Cable sizes
  - ◆ Fuse, MCB sizes
  - ◆ Earthing connections
- ◆ Machine foundation
- ◆ Transmission and distribution line
  - ◆ Transformers, switches, fuses, earthing points, lightning arrestors.
  - ◆ Distances
  - ◆ Wire/ cable sizes
  - ◆ Name of sub circuits (eg. village name)

Documentation of all the necessary documents is very important not only for the execution of the scheme, but for the repair and maintenance works also. Without the proper and adequate documentation, the system would be

considered incomplete. The following documentation should be made available at a micro-hydro installation.

#### ***4.3.9 Measurement Book and Audit***

In the measurement book, measurement of all the works done in the site (actual works done) should be documented (civil, electrical and mechanical) in a prescribed and systematic manner. The quantity of works done should be assessed as per the actual rate, bills of purchase should be referred to prepare a valuation of the scheme. The rate at which the works are carried out should not exceed the rates approved by NABDP unless there is strong justification and the complete works should have been done as approved in the detailed project report. In respect to the *Measurement Book (MB)*, the costs incurred while carrying out the works should be discussed and approved in the *CDC*, which should be followed by formal audit by MRRD internal control and or a officially recognized firm. The audit report (public and formal) should be forwarded to all the stakeholders. The documentation should include the followings.

- ◆ Detail measurement of each component
- ◆ Quotations and bills of purchase and the minutes of CDC/MHFG to purchase
- ◆ Valuation of works (actual)
- ◆ Disaggregation of costs (local, non-local)
- ◆ List of community members that contributed their voluntary labour (local cost)
- ◆ Minutes of the CDC approving the total cost
- ◆ Audit report (if done any)

#### ***4.4 Installation of Electro-mechanical Equipment***

The community people are mobilised to the required extent for the installation works. Besides, the operators selected by CDC are required to work with the installation team. This will also act as 'on the job training' for the operators. The active participation of the community members during the installation period is essential as they are found to be very effective, not only for reducing the installation cost, but for timely completion and instant conflict resolution which might occur, especially during the transmission/distribution works.

## 5. CONCLUSIONS

This guideline has been prepared on the basis of experiences gained in Nepal's Rural Energy Development Program and Afghanistan's National Solidarity Program. This guidelines is requested to be followed by Engineers and technicians who are directly involved in the survey, design and implementation of micro hydro schemes. It is envisioned that the guidelines would also be useful to all the persons who are involved for the development of micro hydro sector in the country and abroad.

## 6. REFERENCES

1. Technical Guideline for Installation for Micro Hydro Demonstration Projects - REDP
2. MH Design Manual – Adam Harvey
3. Guidelines for Detailed Feasibility Studies of Micro Hydropower Project, AEPC/ ESAP-2004

## **Annex 8. ERDA Implementation Guidelines**

### **Background**

In recent years, Afghanistan has witnessed a spate in installation of micro hydropower plants (MHP) for rural electrification. It is estimated that more than 1000 MHP have been installed in the country. However, the performance of these plants are mixed at best. It is believed that many of these plants are not generating electricity as envisaged while many others have become totally dysfunctional. Studies show that the problems starts right from site identification to survey, design, fabrication of equipment, installation, operation and management. In short, the entire procedure in practice isw doubtful. The implementation modalities in practice does not provide adequate support to the communities to plan, install, operate and manage the system, there is very little oversight in the implementation process from the promoter. These guidelines aim to help ameliorate the situation by providing a systematic procedure for implementing MHP for ERDA personnel. However, these Guidelines could be used by other organizations involved in promotion of MHP in Afghanistan and elsewhere.

The Ministry of Rural Rehabilitation and Development (MRRD) launched Energy for Rural Development Afghanistan (ERDA) with UNDP's support in 2008. ERDA is a component of a much larger National Area Based Development Program (NABDP) of MRRD. Among others, ERDA aims to demonstrate innovative methods of implementing MHP and other rural energy systems that suits the Afghan context. In this regard, ERDA is supporting the communities in several CDCs to install and manage MHP. These guidelines are prepared to help ERDA personnel to help support the implementation procedure so that the communities take ownership of the projects from the beginning, technical issues are addressed and the goal of the government in providing sustainable energy to rural Afghanistan is realized.

These Guidelines are not carved on stones and are just guidelines for ERDA engineers to help the local communities. As the experience with implementation procedure accumulates the guidelines will be updated or totally revised as per the need. These Guidelines should be used in conjunction with NABDP's Operational Guidelines.

These guidelines have borrowed heavily from Implementation Guidelines of Rural Energy Development Program, Nepal which promoted community based rural energy systems. However, effort has been made to incorporate learnings from Afghanistan to make them useful for the local context.

## THE GUIDING PRINCIPLES

The Operational Guidelines of NABDP is based on certain principles that are equally applicable for ERDA. It is expected that the user(s) of this Guidelines will adhere to these principles in order to increase the efficacy and efficiency of their implementation works.

The principles are as follows:

1. **Socialisation:** Social contacts develop empathy with the community people. These are important factors for success of the projects as these work as lubricants required for project mobility. It establishes closeness and openness with the community people. It is so important in the war-ridden circumstances of Afghanistan to socialise the project activities and the personnel. This includes the socialisation of women within acceptable cultural practices. This will help avoid misunderstandings.
2. **Simplicity:** Since the projects are implemented by the the CDCs or Cluster of CDC (CCDC), the processes, procedures, rules and regulations governing the project implementation should be as simple as possible. Working methods should be discussed with the stakeholders and verified with them in order to ensure that they understand these properly and adequately. Simplicity also helps raise confidence among the stakeholders to engage in development activities.
3. **Community Empowerment:** All actions undertaken during the implementation of the project will be directed towards empowerment of the DDAs and CDCs in particular and the community people in general. The community will be empowered only when they are allowed to take decisions on policies, assets and formation of committees, which affect the output and outcome of the projects. Participation of the relevant stakeholders, including women, in every step of decision making will be ensured.
4. **Accountability:** The DDAs, CDCs and individual persons (project care takers) designated for the purpose of implementing the

projects must be answerable to the beneficiaries for their decisions, actions and behaviours. Beneficiaries, including women, must be satisfied with the project processes, progress and expenses. They have the right to ask and should get clear answer from DDAs, CDCs and contractors.

5. **Transparency:** All decisions and actions related to the projects should be transparent. The DDAs and the CDCs should readily make information available to the general public and the funding agencies on all aspects of the project implementation - for instance, the decision process, criteria used, rules and procedures, expenditures, performance vis-à-vis plan etc. Transparency reduces uncertainty related to the project implementation, and also helps inhibit corruption.
  
6. **Adherence to Quality:** All NABDP projects will be implemented as per the approved criteria and specification. Quality works provide the expected benefits and become more durable. ERDA in coordination with the DDAs, will take all responsibility to ensure that the works have been done as per the norms and standard it has developed.
  
7. **Ownership:** Ownership is a process in which the beneficiary community takes initiative to implement the project in the beginning and responsibility to sustain the project. In order to raise the feeling of ownership, communities are required to contribute to the project. This contribution may be in cash or kind or both, in the form of labor contribution or through the configuration of a maintenance system. This is important for sustainability of the project as well.
  
8. **Stakeholders involvement:** Successful Integrated Comprehensive Rural Development can only be achieved by joining hands with other national and international partners, ministries, UN agencies, donors, NGOs, private sector, universities, etc.

### ***1. Definition of Micro Hydropower***

Micro Hydropower is defined as those hydropower plants with the installed capacity of less than 100 kW.

## 2. *Project Identification*

**District Development Plans:** The basis of identifying micro hydropower projects for implementation is the District Development Plans (DDP). Projects might be identified by the communities (Community Development Councils or a cluster of councils, traditional organizations, government officials, non-governmental organizations (NGO) or individual entrepreneurs but have to be endorsed by the respective Community Development Council/s and District Development Authority and incorporated in DDP.

ERDA will provide technical assistance to undertake pre-feasibility and detailed study of the projects. The pre-feasibility will consider the following factors to prioritize the potential MHP.

- i. **Geophysical Conditions:** There should be adequate flow in the river, adequate head at the site and stable terrain. Normally, a MHP is a run-off the river type scheme, so there will be no reservoir. The installed capacity of the plant is calculated on the basis of the minimum flow. The site should be close to the load center and benefit maximum number of households.
- ii. **Distance from Electricity Grid:** The national electricity grid is unlikely to reach the proposed MH site within the next five years.
- iii. **Commitment of the community:** The community should be willing to provide voluntary labor for construction of the scheme, transportation of construction material and electromechanical equipment from nearest road head as well as collection of locally available materials like sand, stone, aggregate and timber and contribute cash or take loan, if needed. The community has to contribute at least 10% of the total project cost. NABDP Operational Guidelines emphasizes on selecting beneficiary community based on the size (percentage) of their contribution to the total project cost.

Besides, each household should be willing to pay for consumption of electricity and the community should establish a Micro-hydro Operation Fund (MOF) to operate and maintain the plant once it is operational.

- iv. **Productive Use of Electricity:** There should be possibilities of using electricity for various productive-uses like enhancing agricultural production (e.g. lift irrigation), agro-processing (e.g. milling), electric

cooking and off-farm enterprises (e.g. saw-mill, bakery, stone-crushing, etc.)

- v. **Multiple Use of Water:** In addition to producing electricity, there should be possibilities of using the water for other purposes, namely irrigation and drinking water.
- vi. **No other MHP:** To avoid duplication, there should be no other MHP in the CDC. If there is another MHP providing electricity to a small percentage of population, an Memorandum of Understanding clearly outlining the area of operation of each MHP has to be signed by all the parties including CDC and DDA involved.
- vii. **No Water Right Conflicts :** There should be no conflict on the water use right in the source stream/river. The community is solely responsible to resolve conflicts, if any, before implementation. The community has to provide an evidence in writing either from local Mirab (Water Headman) or DDA, incase there is no Mirab, stating their rights for water-use.

In this analysis, geophysical stability and absence of water rights conflicts are taken as preconditions. Geophysical stability ensures stable civil structures without incurring excessive costs. It has to be ensured that there is no water rights conflicts, or even if there is, it should be resolvable.

**Viii Security Situation:** Local security to implement the project is a precondition. ERDA will assess the security situation and only support projects in areas it finds secured enough. Besides, the CDC and DDA have to provide written assurance of providing security to all ERDA personnel, consultants and supplier/installer before a project is taken up for development. DDA also has to guarantee of safe access to all project personnel to and from the project site. If ERDA feels that the security situation is not good enough at any point in time it will withdraw all its personnel and halt its activities. However, if the project is in advanced stage of development and works can be carried out without direct supervision of ERDA, implementation can proceed if the DDA takes total responsibility for technical backstopping and supervision.

Based on the above mentioned criteria, potential schemes are screened for detailed study and further analysis. The projects thus identified are presented to the DDA for discussion and approval. Preference will be given to potential schemes whose per kilowatt cost is less than US\$ 3000. Following technical features will help reduce the cost per kilowatt.

- Natural intake for water diversion,
- Existing canal,

- Lower discharge and higher head (may not be true in Afghanistan given the limitation in producing Pelton!),
- The farthest point from the power house to the load centre should not be more than 4 kms and the voltage drop at any point of the system not more than 10 % without transformer.
- Clustered settlement will reduce cost and simplify the distribution system.
- Availability of construction materials like stone, sand, aggregate, wooden poles, timber, etc. in the vicinity

### 3. Detailed Study and Detailed Project Report

ERDA will undertake the feasibility study cum design of MH schemes either with its-own personnel or short term services of experts depending on the availability of personnel and complexity of work.

The objective of the feasibility cum design study is to determine the viability of selected MH schemes, ascertain the plant capacity, prepare necessary designs and make detailed cost estimates and prepare a Detailed Project Report (DPR). A separate Environment Assessment (EA) report of each MHDS is prepared by ERDA. An EA report includes information on the existing environment and natural resource and the anticipated changes that installation of MHP may cause. The report identifies potential environmental impacts and recommends mitigation measures.

A *public-hearing* participated by at least one male and female from all potential beneficiaries households has to be organized to finalize Detailed Project Report and Environment Assessment Report.

### 4. Technical Review Committee

Technical Review Committee (TRC) will be set up at the central level to review technical as well as financial viability of potential MHP. The TRC helps in ensuring the realistic design and cost estimates. The TRC reviews, recommends modifications, if necessary and approves MH schemes for implementation. No MHP gets support from ERDA unless approved by TRC.

### 5. Agreements

A Tripartite Agreement will be signed between CDC, DDA and MRRD outlining roles and responsibilities of each party regarding the implementation of the MHP project. See **Annex...** for the Format.

A Public Hearing will be organized in the community before the signing of the Agreement. Following issues will be discussed in the meeting.

- Proposed project starting and completion dates

- Implementation modalities
- Community's contribution
- MRRD/NABDP support
- Roles and Responsibilities of all parties involved
- Establishment of Micro Hydro Functional Group (MHFG) and Micro-Hydro Operational Fund (MOF)
- Roles and Responsibilities of Operators and Manager
- Emphasis on revenue generation for sustainable operation and management
- Other issues of concern for community, DDA, ERDA

## 6. Micro Hydro Functional Group (MHFG)

ERDA considers enhancing the capability of the rural communities to plan, implement and manage rural energy systems in particular and rural development activities in general an essential vehicle for sustainable development. Emphasis is given to self-governance and 'genuine' participation of local people from planning to successful operation of micro hydro and other rural energy schemes.

The community should form a Micro Hydropower Functional Group (MHFG) with representation from all the Community Development Councils (CDC) benefitting from a MHP. The number of executive members will depend on the size of the plant, number of households served and the spatial distribution of the village. Efforts should be made to have representation from women as well as all ethnic and economic groups and geographic locations within the community. MHFG will have a chair, secretary, treasurers, etc.

MHFG will be responsible for all activities related to the installation and operation of the MHP. It will be responsible for resource mobilization, construction planning, construction of the civil works and pole erection. It will also be responsible for identifying potential manufacturers/suppliers for electro-mechanical equipment, evaluation of their proposals and identifying the best options, contracting and supervising and closely working with the contractor to smoothly install the system. After completion and commissioning of the project, MHFG will be responsible for sustainable operation and management of the plant.

Besides, MHFG will also be responsible for formulating rules, setting tariff, sanctioning non-payment and informing the users on the general condition of the plant. MHP operators and managers will be hired and supervised by the MHFG.

The community is the owner of the MHP and the MHFG on behalf of the community has to undertake all the necessary activities required of a owner. ERDA's role will be advisory and facilitating the MHFG in achieving its goals.

MHFG will organize a Monthly Meeting during the construction phase to announce the monthly target, progress made, expenditure, plans for next month, and other issues related to project implementation. Participation from all beneficiary households and representatives of DDA and ERDA will be encouraged. It is encouraged that MHFG will continue the practice even after the completion of the project to announce and get endorsement from all beneficiaries for major decisions, future plans, monthly income and expenditure, etc.

All the decisions of the MHFG/CDC/DDA will be recorded along with the signatures of all those present in minutes books specifically kept for the project.

## **7. Action Plan**

MHFG has to prepare an action plan with the support of ERDA for the implementation of MHP. The Action Plan includes activities like resource mobilization, land acquisition, fund transfer to MHFG from various sources, loan processing, quotation collection and contract with supplier/installer, transportation of electromechanical equipment, collection of local material, construction of civil parts, installation of electromechanical equipment, installation of distribution network, service wire connection, house wiring, test operation and commissioning.

While preparing the action plan, manufacturer's fabrication and supply schedule, farming and other workload of the communities, weather conditions, festivals and other factors affecting the installation works and community's workload have to be taken into consideration.

## **8. Registration of Water Use**

To avoid future water use conflicts, MHP should be registered at District Development Authority (DDA). Traditional water rights (*Hak Aba*) will be taken in consideration while registering. An effort will be made to establish a Water Use Registration Unit in DDA that will include representation from Mir Abs of the district.

## **9. Resource Mobilization**

The resources for constructing the MHP are mobilized by the Micro Hydro Functional Group (MHFG). The DPR groups all the material and labor required into two categories, local and non-local. The community is responsible for mobilizing all the resources. Local resources are

mobilized through voluntary labor. MHFG is responsible for managing the installation with technical support from ERDA.

ERDA/MRRD, CDC and DDA will sign a Tripartite Agreement that mentions ERDA's support to CDC and DDA and the roles and responsibilities of each party. ERDA's financial support will be transferred to the CDC as per the Agreement. (See Annex ..... for the Agreement format)

#### **10. Micro-Hydro Operation Fund (MOF)**

The CDC will establish a separate bank account for the purpose of installation and operation of the MHP. The account will be called Micro-hydro Operation Fund (MOF) and will be used only for the above mentioned purposes. ERDA's financial support will be channeled to this account and MHFG will pay for all MHP related activities through it. After the commissioning of the plant, revenue generated will be deposited in this account and the fund will be used for operation and maintenance.

#### **11. Land Acquisition**

The community is solely responsible for acquiring land for the canal, powerhouse and other civil structures, penstock, erection of poles, etc. The CDC/MHFG and the land owner/s sign MOU so that conflicts do not arise in future. The ownership has to be transferred to the CDC wherever possible.

#### **12. Quotation Collection and Identification of Supplier/Installer**

MHFG calls for quotations for supply and installation of electro-mechanical parts as per the Bill of Quantities (BOQ) in the DPR. Only manufacturers/installers pre-qualified by National Solidarity Program (MRRD/NSP) are eligible to fabricate, supply and install electromechanical equipment.

MHFG has to negotiate with supplier/installer for the best 'offer' – cost reduction, quality products, on-time delivery and installation, etc. All the collected quotations are analyzed and discussed in the MHFG. Besides costs, past performance of the supplier/installer, qualification of installation team, quality of equipment offered, supply and installation time, etc. have to be analyzed. The community identifies, in consensus, the best supplier/installer and directs the MHFG to sign the Contract for supply and installation of electro-mechanical equipment on turnkey

basis. Contract Format is attached in **Annex...** Technical specifications, quality of service and product, past performance and timeframe are taken into consideration to identify suitable suppliers/manufacturers. ERDA will provide technical assistance to the MHFG in identifying the right manufacturer/supplier.

It needs to be emphasized here that the cheapest option is not always the best option. MHFG has to make sure that the goods offered are as per the specifications given in the DPR and all the required documents are furnished by the supplier/manufacturer. If there is any deviation from the specifications given in the DPR, MHFG has to get prior approval from ERDA.

### **13. Construction**

Community is solely responsible for the construction of all civil components like diversion, intake, headrace canal, desilting basin, forebay, penstock supports and anchor blocks, power house and tailrace canal and spillway and overflow. ERDA will provide technical assistance to the community in undertaking these activities through a technician hired by the DDA. It is mandatory for the community to consult the technician in all construction works. The technician is responsible to keep record of daily activities in a Measurement Book. Fund is released only after the verification of the Measurement Book and the actual job done.

All the local material and unskilled labor required for installation of electromechanical equipment and distribution system is provided by the community. The supplier is responsible for the installation of the equipment with communities' support. MHFG arranges labor according to the installer's schedule and keeps record of voluntary labor provided by each household.

The manager and operators of MHDS selected by the community are required to actively support the supplier in the installation work.

The MH Technician provided by ERDA through DDA will provide technical backstopping. He/she will support the community and monitor the work.

### **14. Commissioning and Project Completion Report**

13.1 **Test Operation:** It is mandatory to undertake test operations in the presence of the representatives of MHFG, CDC, DDA, ERDA,

supplier/installer and other stakeholders, if any. Test Operation includes both visual checks and output measurements.

Testing and commissioning should be carried out as per '**Guidelines for Testing, Commissioning and Handover of Micro-Hydro Projects**' prepared by ERDA. The results of visual checks and performance tests have to be recorded in the given format and signed by the representatives of all institutions.

- 13.2 Power Verification:** With the given head and the flow, actual power output should not be lesser than the designed output. If the anomaly is due to the negligence of the Manufacturer/Installer, Afs.../kW will be deducted for each reduced kW from the final payment.
- 13.3 Warranty Period:** At least one year's warranty period has to be provided by the supplier/installer on the electromechanical equipment of the MHP, which has to be clearly stated in the Contract signed by the supplier/installer and MHFG. During the warranty period the installer/supplier must make **two routine checks** of the plant and give suggestions to MHFG for better operation and management. The supplier/installer is responsible to rectify any problem arising due to poor workmanship, material and supervision. The community is responsible for problems due to negligence on part of the operator and manager.
- 13.4 Formal Audit:** CDC/MHFG has to undertake formal audit of MOF every year from a certified auditor.
- 13.5 Public Audit:** CDC/MHFG is responsible to carry out a "Public Audit" of all income and expenses incurred during the construction of the scheme. All the beneficiaries, members of the MHFG and CDC and representatives of ERDA and DDA have to be present in the function organized for the public audit. The manager reports all the resources mobilized from different sources as well as detailed account of all the expenditures. The Manager and MHFG members are accountable to furnish answers to the queries raised. If all the members agree to the income and expenditure statement provided, the decisions are recorded and signed by everyone present in the meeting.
- 13.6 Project Completion Report:** MHFG has to prepare a Project Completion Report. The Report contains actual resource mobilized and expenditure, details of civil works actually undertaken, specifications of electromechanical equipment installed, actual cost of each component and the performance of the scheme during the one year warranty period. This report gives the actual valuation of the scheme. ERDA, DDA and CDC will support the MHFG in preparing the report.

**13.7 Participatory Evaluation:** One year after the completion of the project, a participatory evaluation will be undertaken in the village by all the stakeholders – all beneficiaries, MHFG, CDC, DDA and MRRD/ERDA. The evaluation will focus on whether the project has achieved its objectives, major issues, mitigation measures, etc.

## **15. Operation and Management**

In small plants the operator and manager is usually the same person; or, the manager also assists in operation and maintenance. For plants larger than 50 kW, there should be two different positions; both for a manager and operator; but this again depends on the level of management skill of the operator and also the interest and commitment of the manager. In short, the decision on the number of operators and whether or not to have a manager should be guided by the revenue generation. A MHP should be able to generate enough revenue to pay for the services of the hired personnel.

The operator is responsible for not just running the plant but also for maintenance and occasional repair. Therefore, he must understand the location and functions of each machine and components. He should be continually listening, testing and checking for malfunctions and problems. He needs to keep uppermost in mind that prevention is always better than cure. His responsibility will normally be for all equipment and structures from source to distribution including routine inspections, operation, loading of the system, distribution and good condition of equipment.

The manager is responsible for overall management of the plant including organization, planning, management, budgeting, tariff setting, keeping of books, etc.

**Reporting:** The Manager and the Operator report to MHFG every month. They report on the state of the scheme and difficulties, revenue collected and the names of the defaulters which are announced in the meeting. It is the responsibility of the MHFG and the concerned CDC members to ensure timely payment of the electricity bills by all members. The incomes and expenditures statement is presented at the monthly mass meeting by the manager.

**Safety Measures:** As most of the villagers are using electricity for the first time, a number of "Safety Classes" are conducted for creating awareness among consumers. MHFG and ERDA are responsible for

organizing such classes in all schemes. All the beneficiaries, including women and children are sensitized on the hazards of electricity and the proper way to use it. ERDA will provide a "Safety Manual" to MHFG.

## **16. Rules and Regulations Regarding the use of Electricity**

General rules and regulations regarding supply and consumption of electricity are given below.

- i. Every beneficiary household should provide voluntary labor or equivalent in cash for the installation of the MHP.
- ii. Each household should pay a fixed charge for connection.
- iii. The household is responsible for the service wire, cutout and house wiring.
- iv. MHFG has the right to accept or reject the request for the power subscription/demand.
- v. Household is connected to the system only after ensuring the quality of house wiring.
- vi. MHFG has the right to fix the tariff for domestic, industrial or other consumers. The rates may be changed periodically with consensus decision.
- vii. A customer should pay the monthly bill by the date fixed by the MHFG. Delay fine, which is determined by MHFG, is applied then after.
- viii. In case the monthly fee is not paid on time, MHFG has the right to levy fines.
- ix. In case a consumer is found to indulge in pilferage – consuming more power than subscribe – MHFG has the right to levy fine.
- x. In case of repeated offense regarding the above points, MHFG has the right to disconnect service to the customer. Clearance of dues, delay fine and connection charge are necessary for re-connection.
- xi. MHFG is not responsible for any damage due to electric faults beyond its control.

## **17. *Productive-use of Electricity***

Not only to increase the load of the micro hydro plant and ensure financial viability of the system but also to realize ERDA's goal of enhanced rural livelihood emphasis is given on utilizing the electricity for various productive uses. End-uses are both domestic appliances and electricity based micro enterprises. Promotion of end-use technologies would support in improvement of quality of life through drudgery reduction and improvement of health conditions, economic development through value addition in local products and employment generation and environment protection through

reduction/replacement of fuelwood and fossil fuels. Table 1 below outlines the ways and available technologies to achieve this stated goal.

MHFG, with support from ERDA prepares a comprehensive end-use promotion package. ERDA supports the prospective entrepreneurs in adapting technologies to local conditions and establishing the enterprises through MHFG/CDC. ERDA also supports the MHFG in end-use and electricity based enterprise promotion.

Besides, ERDA also emphasizes that other income generating activities are promoted so that even the poorest community members have enough additional income to pay for their lighting needs. ERDA supports mainly through linking community needs to the programs of provincial/district level government line agencies and other donors/NGOs involved in the field. Based on the needs of the communities, ERDA coordinates with line agencies to identify training and other supports.

ERDA provides limited financial support through CDC for the development of end-uses and electricity based micro enterprises. The support is provided to interested entrepreneurs in terms of soft loans or venture capitals. CDC/MHFG decides the enterprise and amount of support for the applications received from the community members. In this context, ERDA provides one time support as endowment fund for end-use promotion at the rate of 10,000 Afghanis per kilowatt installed capacity.

Interested entrepreneurs have to submit a 'business plan' outlining the type of enterprise, energy requirement, source of raw material, expected market, process, equipment and machinery required, capital required, etc. The entrepreneur has to bear the cost of land, building, etc. and ERDA support will be used mainly for acquiring and installing machinery. CDC/MHFG decides on the proposals and forwards the selected ones to ERDA for verification and final approval. The fund is then transferred to CDC for the establishment of the enterprise. ERDA encourages the communities in identifying and adopting appropriate end-use technologies based on local resource and opportunities. If the concerned CDC/MHFG does not submit any proposal to ERDA within six months' of commissioning of MH scheme, it automatically forfeits the financial support allocated to it by ERDA for end-use promotion.

Besides lighting, the most common end-use of MHP are agro-processing such as grinding corn or wheat and oil expelling. Broiler farming is another popular activity in the rural communities which could be undertaken with the access to electric lighting. Other common end-uses include stone crushing, sawmill, rural bakery, etc.

**TABLE 1: PROMOTION OF END USES FOR ENHANCE RURAL LIVELIHOODS**

FOR	THROUGH	WITH/SUCH AS
IMPROVED QUALITY OF LIFE a) Drudgery Reduction	1) Reduction in fuelwood collection time 2) Reduction in drinking water collection time 3) Mechanization of Milling process 4) Mechanization of transport sector	* Electric cookers * Water Pump * Huller, Grinder, Expeller * Ropeways
b) Health Improvement	1) Better Lighting 2) Elimination of smoke 3) Life saving medicine 4) Biomedical equipment	* Electric bulbs/tubes * Electric cookers and bulbs * Refrigeration * X - ray machine
c) Recreation	1) Establishment of recreation center	* TV/ Video/High Vision Hall
ECONOMIC DEVELOPMENT a) Value addition	1) Establishment of cottage and small industries 2) Production of high value cash crops	* Saw Mills, Weaving, Bamboo Plywood Manufacture, Paper Making, Food Processing (juice and jam) making, fruit and vegetables drying, cold storage bakery, auto, and mechanical workshops and furniture making * Lift irrigation
b) Employment Generation	1) Establishment of cottage and small industries 2) Improved Irrigation	* Above nationed industries
ENVIRONMENT PROTECTION a) Forest Management	1) Reduction of fuelwood consumption	* Bijuli Dekchis, Heat Stroage Cookers
b) Replacement of fossil fuel	1) Replacement of kerosene for lighting 2) Replacement of kerosene for cooking 3) Replacement of diesel for motive power 4) Replacement of kerosene in refrigeator	* Electric Lamps * Bijuli Dekchis, Heat Stroage Cookers * Electricity operated mills * Electric refrigerator, cold store
Information and Communication	1) Computers 2) News	* Internet/email * TV/Radio

Change/add end-uses for Afghanistan

## 18. *Cooperative*

For the sustainable operation of micro hydro schemes, MHFG could be registered as a company or a cooperative. However the process for registration should begin only after the successful operation of MH scheme for at least six months. The members of the MHFG, CDC, DDA and ERDA representative should discuss this issue extensive before any decisions are made.

## 19. *Entrepreneurs*

ERDA also encourages involvement of private companies or individual entrepreneurs in development and management of MHP. However, ERDA's financial support is channeled through the CDC. Any domiciled entrepreneur or group of entrepreneur can develop and manage MHP with the written authorization of CDC and approval of DDA and ERDA. The interested entrepreneur has to sign a written contract with the CDC on transferring fund as soft loan, interest rate, payment schedule, etc. The contract should also include management plans that includes tariff fixing procedures, rules and regulations regarding electricity uses, etc. ERDA reserves the right to approve or disapprove such projects.

## 20. *Monitoring & Evaluation*

ERDA emphasizes on project monitoring, reporting and evaluation. Monitoring is integrated within the implementation modality in such way that problems are identified are various levels and mitigated. The beneficiary community monitors the activities of each other regarding labor contribution and rules-following, it also monitors the activities of the MHFG and CDC personnel. DDA monitors and supervises MHP implementation and ERDA provides technical backstopping and monitors activities related to rural energy promotion.

Monitoring and reporting is an ongoing, regular process during implementation; evaluation occurs periodically and when a project has been completed. The bases for project monitoring are the project proposal and the agreements, with anticipated details on activity and budget planning, community contribution, plans and designs.

Specifically, the followings have to be looked at:

- Are activities taking place as scheduled?
- Is the quality of work as planned?
- Are outputs being achieved as planned?
- How have the beneficiaries responded/reacted to the project?
- Has there been any unplanned input required to achieve output?
- Any need for revision of current implementation plan or part of it?
- Likelihood of achieving the target?
- What are the recommendations to improve upon the current situation?
- Were the intended impacts achieved

## **Annex 9 Operation and Maintenance plan for MHP Projects**

For the sustainability of Micro Hydro Power projects it is necessary to develop a good operation and maintenance plan. At the beginning of the subproject choosing phase the community must be informed of the expected expenses which have to be paid by the community on monthly base. A well functioning money collecting system has to be implemented in the community.

Trainings of technicians and revenue collectors or payment have to be planned and included into operators' training.

The ERDA is expected to introduce the concept of operation and maintenance from the beginning of the project to engage and make familiar the community with the O&M plan for sustainability and keep operational the system in the future. And will also it can increase the community finance collection system as well

### **IMPLEMENTATION PHASES**

1. MHP user group executive committee need to create (CDC leader, Deputy, Manager, Treasure, Operators, Secretary, members)
  - Executive have to respected by all
  - Operators, Executive group have to select educated persons as operators
  - Technical advices for (power supply wire to houses and house wiring, type of lampas end-uses) have to identify
  - Ownership documents of the plant before the plant is put into implementation should clarify to all community
  - Responsible persons / manager / operators, tariff setting / updating, treasurer have to identify
  - The service wire to connection to the houses can do by the qualified person
  - Make electricity rules
  - Arrange local material for constriction
2. Electricity rules and regulations have to explain and past in certain places
  - Names of executive committee members
  - List of electricity subscribers
  - Name and list of responsible persons operator, cashier, etc
  - The collected tariff has to control by executive group monthly with cooperation of treasurer
  - Application for connection from each subscriber
  - Connection fee / equity, later connection
  - Wiring of subscribers' premises checked by trained person

- Subscription card with client details, responsibilities sample format for electricity application form including payment recorded column

**Treasurer**

Assumes responsibility and maintains accounts of the project funds including loan, donations, local cash, revenues, expenditures etc.

**Secretary**

Conducting and agenda for each meeting prepare minute of each meeting, reads out the minutes and inform to all members, the minutes signed by all present usually the plant manager

**Members**

Represents and relays all result and decisions of meeting to his ward or group of houses and convince them to be care for apply

**Application for supply of electricity**

I would like to apply for supply electricity to the following address for which I shall pay bills and deposits when needed, I also fully agree to the condition of electricity supply as mentioned

Not: the applicant has to submit the above sentences on a separate sheet include his signature and date.

This page have to submitted to every applicant and candidate, one copy in the archive as well

Name of the house owner.....

Date of issues.....

	Description of consumers	Capacity of consumptio	Number of consumptio	Power Factor	Kva	Total power required	Time of usage
--	--------------------------	------------------------	----------------------	--------------	-----	----------------------	---------------

Address.....

Propose of electricity.....

Name of applicant		n	n				

*Identification of the (Subscription type) and energy used by beneficiaries*

Motors capacity KW	Number of Motors	Total charge Kwh	Number of tube lamps	Total charge for lighting	Number of TVs	Charge/ TV	Total charge for TVs	Total change have played to

*Monthly Tariff or Payment Rerecording Table - from ..... To ..... Year 2008*

Months	January	February	March	April	May	Jun	July	August	September	October	November	December
Payment or bill												
Date												
Signature												

## Safeguard and system protection

- Grounding of the generator and metal fuse boxes is necessary.
- Transmission lines of electric power inside the village should be installed under ground if reasonably priced.
  
- Pillar for overhead lines should be around 5.5 m high.
- All wire connections should be tidy.
- Green trees should not be used as pylons.
- Automatic switches should be used at the end and beginning of each transmission line.
- For illegal connections and user have to be a financial penalty rule
- The transmission lines must be connected to pylons using insulators.
- Volt and ampere meters have to be in each main fuse box.
- Kwh meters have to locked in small boxes
- Aluminum and copper lines should not be connected.
- All connections must be insulated.
- Electric systems must be fitted with sensitive automatic fuses to protect the generator from overload and short circuits.
- Electric plants projects need a responsible and trained operator (a second operator should also be trained and able to take over when the first is not available).
  
- The responsible person should get a sound training about electricity and the mechanical systems of the MHP plant.
  
- Only trained operators should have access to the power house.
- Before starting the generator the main switch must be closed ('OFF' position) to isolate it from the distribution system.
  
- Before starting the generator connection, ELC connections, water in the blaster tank and fan belt checking is very necessary.
- After every 200 hours the generator needs service and the following has to be checked
  - ▶ Bearings greasing
  - ▶ Fan belts
  - ▶ Electrical connections
  - ▶ Blaster loads
  - ▶ Pulley level

## Regulations and rules for payments

- Committee to decide and change the regulation time to time if required
- Final date for paying earlier month's bill (second of the next month)
- All beneficiaries have to receive the second page format
- Penalty for late payment (10% per month)
- Disconnection for non-payment for longer time (2 months)
- Client's are responsibility for safe use of electricity
- Client's responsibility for cost of replacement MCB/meter + service charge
- No connection of one house from another unless approved by the executive group
- Manager authority to inspect subscriber's premise
- Salaries and wages and operators arrange by executive group
- Office expenses (meetings, rent, stationary) organize by executive group
- Electric energy charge per each 20 watt tub lamp 30 Afs/ month
- Electric energy charge for small end uses and government offices per each unit 5 Afs/Kwh

## Maintenance and Operations regulations

- Maintenance and repair fund monthly (4 to 5%, bank deposit)
- Replacement and depreciation fund monthly (7%, bank deposit)
- The operators salary have to be paid after tariff collection monthly
- The bill and revenue have to collect by operators and executive group representative
- Operator is responsible for damages beyond him
- The technical and electrical problem repaired, removing the light and other explanation is the responsibility of operators
- Updating tariff (inflation, new situation / requirement)
- Training during construction and implementation to contractors, Basic skill training and on job training by equipment installer,
- operator turnover, the operator have to train one person and make him ready before to leave
- scheduling maintenance works by manager

## General responsibilities

- Do not allow unauthorized access to plant(power house)
- Maintain plant keep clean the equipment, waterway and around as well
- Maintain safety in powerhouse and along the transmission and distribution lines

- Keep inspection route clear for penstock, lines
- Fill in operating condition and maintenance works in log sheet daily
- Duty rotation - 1 operator at plant and 1 at village or cluster
- Instruct operators for scheduled & emergency maintenance by NABDP/ERDA
- Issue tools, spares to operators during training and keep record
- Define operators' duty rotation by manager
- Listen to and solve customer complaints by manager
- Submit income/expense statement and other reports at monthly meeting among executive group
- Suggest committee major procurement, investment, repair / replacement
- Keep inventories and assist treasurer on book keeping (manager)
- Weekly, monthly, three monthly, six monthly and annual checks and maintenance

**Regulation and rules for maintenance by manager**

- Normal starting up and shutting down procedure(manager)
- Emergency shutting down procedure(manager)
- Submitting daily schedule of starting and shutting for end uses load(manager)
- What to do when the machine shuts down due to fault(manager)
- Starting up after longer shut down(operators and manager)
- Trouble shooting chart(operator)

**Sample of recommended log sheet (manager)**

- Intake gate opening .....%
- Flow control valve of turbine opening.....%
- Belt tension (torque) Ok or Not
- AVR settings..... Volt for month.....

Date & Time	Phase Voltage			Phase Current			Frequency	P.F	Total load	Remarks
	A	B	C	A	B	C				

ID number:

Province :

District :

**Name of DDA**

**Village** :

**GPS location**

Type of turbine	
Capacity of the plant (Kw)	
Total initial of the MHP plant (Afs)	
Cost of training for operator and revenue collector (Afs)	
Depreciation cost (4 to 5% Afs)/ month	
Repairing and spare part (7 % month, Afs)	
Yearly total cost divided by 12 (monthly cost)	
Depreciation and repairing cost per month (Afs)	
Lubrication services per month (Afs)	
Salary of operator per month (Afs)	
Salary of revenue collector per month (Afs)	
Total cost of depreciation, repairing, operator salary, lubrication per month (Afs)	
Number of families (family)	

Signature of CDC members

Signatures of DDA chair person

Name:

Name:

Date:

Date:



5	Pressure gauge	No		
6	Gate valve	kg		
7	Couplings			
8	Belt			
9	Bearings			
10	Pulley			

**11. Butterfly Valve**

Dia.	Wt. Approx	Unit Price	Specification/Manufacturers
3"			
4"			
5"			
6"			
8"			
10"			
12"			

**12. Crossflow Turbine.**

Type	Head range, mt min-max	Flow range, lps min-max	Power kW	Wt Kg	Unit price,	Turbine efficiency	Remarks

	<b>1-5</b>	55-80					
	<b>5-10</b>	50-100					
	10-15	60-120					
	10-20	50-100					
	10-20	60-120					
	10-20	70-140					
	10-25	80-140					
	10-30	80-150					
	10-40	80-160					
	10-45	90-160					
	15-20	200-400					
	15-20	250-450					
	20-30	250-450					
	20-30	300-475					
	30-40	325-500					
	30-40	350-525					
	40-50	375-550					
	40-50	400-600					

### Electrical components

#### 1. Brush Type Generator

Frame size	Power (kVA)	Approx. Weight (kg)	Price/unit	Remarks
------------	----------------	------------------------	------------	---------

Single Phase				
	5			
	6			
	7.5			
	10			
	12.5			
	15			
	20			
	26			
	30			
	40			
Three Phase				
	6.5			
	7.5			
	10			
	15			
	20			
	25			
	30			
	40			
	45			
	50			
	63			
	75			
	82.5			

## 2. Brushless Type Generator

Frame size	Power (kVA)	Approx. Weight (kg)	Price/unit	Remarks

Single Phase			
	5		
	6		
	7.5		
	10		
	12.5		
	15		
	20		
	26		
	30		
	40		
Three Phase			
	6.5		
	7.5		
	10		
	15		
	20		
	25		
	30		
	40		
	45		
	50		
	63		
	75		
	82.5		

**3. Electronic Load Controller**

SN	Capacity / Phase	Price / unit	Remarks
1	Up to 4kw / 1ph / 220v		
2	4kw - 8kw / 1ph / 220v		
3	10kW - 15kw / 3ph / 380v		
4	16kW - 20kw / 3ph / 380v		
5	21kW - 25kw / 3ph / 380v		
6	26kW - 35kw / 3ph / 380v		
7	36kW - 45 kw / 3ph / 380v		
8	46kW - 50kw / 3ph / 380v		
9	51kW - 60kw / 3ph / 380v		
10	61kW - 70kW / 3ph / 380v		
11	71kW - 80kW / 3ph / 380v		
12	81kW - 100kW / 3ph / 380v		

#### 4. Induction Generator Controller

SN	Capacity/Phase	Price /unit	Remarks
1	1kw /1ph/220v		
2	1kw /1ph/220v		
3	2kw/1ph/220v		
4	2kw/1ph/220v		
5	3 & 4kw/1ph/220v		
6	5 & 6kw/1ph/220v		
7	7 & 8kw/1ph/220v		
8	9 & 10kw/1ph/380v		
9	10kw/3ph/380v		
10	15kw/3ph/380v		

11	25kw/3ph/380v		
12	50kw/3ph/380v		

### 5. Ballast Tank

SN	Specification	Price /unit	Remarks
1	Air Heater with cable 1 kW/220v		
2	Air Heater with cable 2 kW/220v		
3	Water Heater with 3 kW/220v/1ph tank		
4	Water Heater with 6 kW/220v/1ph tank		
5	Water Heater with 9 kW/220v/1ph tank		
6	Water Heater with 12 kW/220v/3ph tank		
7	Water Heater with 18 kW/220v/3ph tank		
8	Water Heater with 36 kW/220v/3ph tank		
9	Water Heater with 54 kW/220v/3ph tank		
10	Water Heater with 72 kW/220v/3ph tank		
11	Water Heater with 100 kW/220v/3ph tank		
12	Water Heater with 120 kW/220v/3ph tank		

## 6. Earthing Plate

Size of the copper plate (mm)	Thickness of the plate (mm)	Price/unit	Remarks
300 X 300	2		
300 X 300	3		
450 X 450	2		
450 X 450	3		
600 X 600	2		
600 X 600	3		

## 7. Positive Temperature Coefficient (PTC) or electronic current cut out

Watt	Current rating (mA)	Price /unit	Remarks

## 8. Energy Meter

Rating (A)	Phase	Price /unit	Remarks
5-20	1		

5	3-phase		
---	---------	--	--

### 9. Miniature Circuit Breaker (MCB)

Rating (A)	Price /unit	Remarks
4		
6		
10		
16		
20		
25		
32		

**10. Moulded Case Circuit Breaker (MCCB)**

Type	Current rating (A)	Breaking capacity (kA)	Price /unit	Remarks
	12-16	6		
	16-20	6		
	20-25	6		
	25-32	6		
	30-40	6		
	38-50	6		
	48-63	8		
	60-80	10		
	70-100	10		
	70-100	35		
	90-125	35		
	120-160	35		
	140-200	35		
	80-125	50		
	125-175	50		
	175-250	50		

**11. Main switch**

- Rewire-able type for single phase

Rating (A)	Price /unit	Remarks
20		
32		

63		
----	--	--

- HRC type switch fuse unit for 3-phase

Rating (A)	Price /unit	Remarks
32		
63		
125		
100		

Transformers Single Phase 230v-1kv (1000v), Dry type

Power (KVA)	Weight (kg)	Price per unit	Remarks
1			
2			
3			
4			
5			
10			

Single Phase 230v-11kv

Power (KVA)	Weight (kg)	Price per unit	Remarks
5			

15			
25			
60			

Three Phase 400v-11kv

Power (KVA)	Weight (kg)	Price per unit	Remarks
15			
25			
50			
100			
125			
160			

**12. Cross Arms-Mild steel**

Length (m)	Weight (kg)	Price (Per/kg)	Price /unit	Remarks

**13. Insulators**

Type	Rate per unit	Remarks
Small 55 X 55mm		

Medium	75 X 90mm	
Large	100 X 110mm	
440v Pin insulator		
11kv in insulators		
11kv Disc insulator		
440v Shackle insulators		

#### 14. Lightning arrester

Rated voltage	Rate per unit	Remarks
0.5kV		
11kV		

#### 15. Stay Wire

Size	Price Rs/set	Remarks

#### 16. PVC Insulated Copper Wire

S.NO	Size	Type	Price /per coil or meter	Remarks
1.	1/18	Single core		
2.	3/22	Single core		

3.	3/20	Single core		
4.	7/18	Single core		
5.	7/20	Single core		
6.	7/22	Single core		
7.	7/16	Single core		
8.	19/18	Single core		
9.	19/16	Single core		
10.	1.5	Single core		
11.	2.2	Single core		
12.	4.0	Single core		
13.	6.0	Single core		
14.	3/20	Double core		
15.	3/22	Double core		
16.	1.5	Double core		
17.	2.5	Double core		
18.	4.0	Double core		
19.	6.0	Double core		

### 17. PVC Insulated Flexible Wire

SN	Size	Type	Price /Coil (or meter	Remarks
1.	14/60	Medium		
2.	14/60	Special thick		
3.	23/60	Special thick		

4.	40/60	Heavy		
5.	14/60	Twin-parallel		
6.	23/60	Twin-parallel		
7.	40/60	Twin-parallel		
8.	23/60	Twin round		
9.	40/60	Twin round		
10.	23/60	Three core round		
11.	40/60	Three core round		

**18. Concentric Cable**

Size	Current rating in still air (A)	Resistance ( $\Omega$ /km)	Price /meter	Remarks
6 Sq.mm	30	4.76		
25 Sq.mm	70	1.14		

**Power Cable Aluminum Conductor**

Cross Section in sq. mm	Armoured Price /meter				Un-armoured Price/meter				
	2 Core	3 Core	3.5 Core	4 Core	1 Core	2 Core	3 Core	3.5 Core	4 Core
2.5									

4									
6									
10									
16									
25									
35									
50									
70									
95									
120									
150									
185									
240									

**19. Power Cable Copper Conductor**

Cross Section in SQ. mm	Armored Price /meter				Unarmored Price /meter				
	2 Core	3 Core	3.5 Core	4 Core	1 Core	2 Core	3 Core	3.5 Core	4 Core
1.5									
2.5									
4									

6									
10									
16									
25									
35									
50									
70									
95									
120									
50									
85									

### 20. Aluminium Conductor Steel Reinforced (ACSR) Conductor

Size in sqmm	Weight (kg/km)	Price /km	Remarks
16			
25			
35			
50			
70			
95			

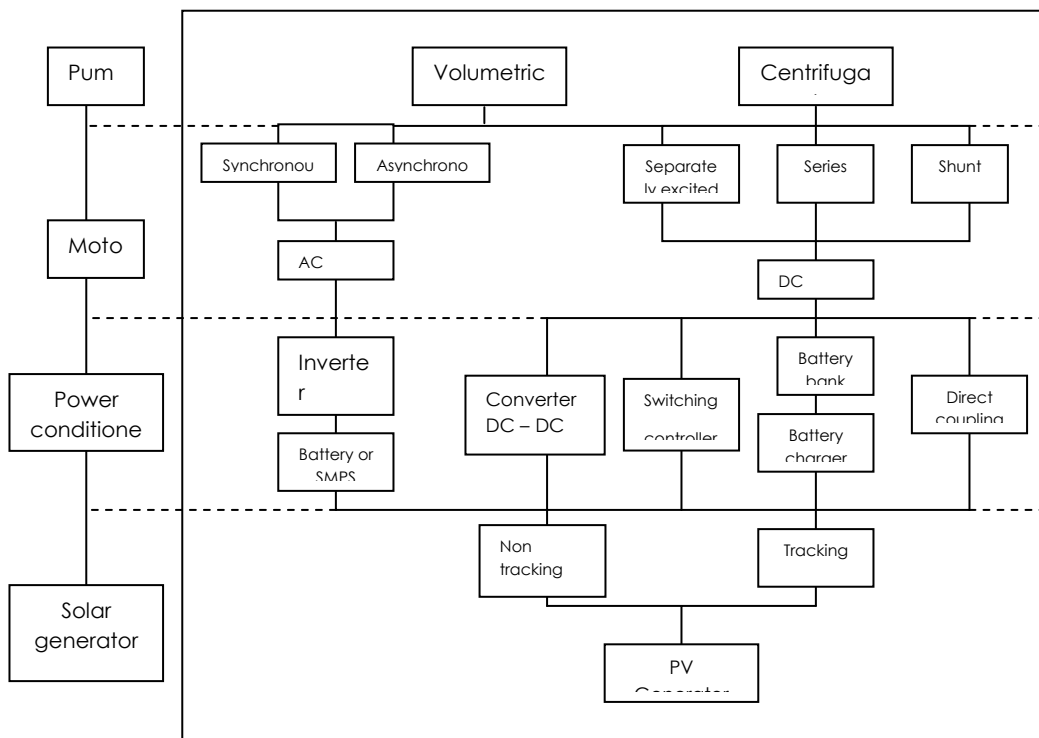




**Annex 12 Design Aspects of Solar Water Pumping System**

**Water Pumping System Configurations**

There is a range of possible components and configurations for photovoltaic water pumping systems which is shown in figure below. Selection of the most suitable components and configurations for each specific application and site is critical to the economic viability and the long-term performance of the system.



Photovoltaic Water Pumping System Components and Configurations

In the simplest photovoltaic water pumping systems, the solar panels are directly connected to a DC motor that drives the water pump. For such simplified systems, DC motors and centrifugal pumps are virtually mandatory, due to their ability to be matched to the output of the solar panels.

Volumetric (also known as positive displacement) pumps have completely different torque – speed characteristics and are not well suited to being directly coupled to solar panels, when volumetric pumps are used, it is therefore common for power conditioning / maximum power point tracking circuitry to be included between the solar panels and the motor / pump to convert the electrical energy into a suitable useable form. Similarly, ranges of motor types are used for water pumping systems, including DC series motors, DC permanent motor, DC permanent magnet brush less motor, AC asynchronous induction motors and AC synchronous motors.

### **Basic Steps in Water Pumping System Design**

Designing a PV water pumping system has two very important aspects:

- selection of the most suitable system component types – this is crucial in providing a low maintenance, long life system of reliability;
- matching of system components – this is a difficult area requiring considerable know-how and expertise, and will ultimately be responsible for the performance of the system with regard to efficiency of operation.

Improved matching can increase operating efficiency (18% case study) apart from 30% increase in efficiency due to manual tracking.

One of the most important questions to be asked before designing a particular system is: "what level of reliability is necessary and to what extent can maintenance be carried out?"

To answer this will indicate a bias towards either a direct-coupled system with simplicity, reliability, low maintenance and long life, or a system, which sacrifices these attributes, to an extent, in order to gain greater efficiency. The features included in the latter, which contribute to the increased complexity, higher maintenance, poorer reliability and shorter life expectancy, include power conditioning circuitry, inverters and perhaps batteries.

Other constraints influence the type of system selected, and each system needs to be designed on its own merits. No one system will be ideal for all application and of all PV applications, water pumping probably introduces the greatest

variability of system design with regard to configuration and component selection.

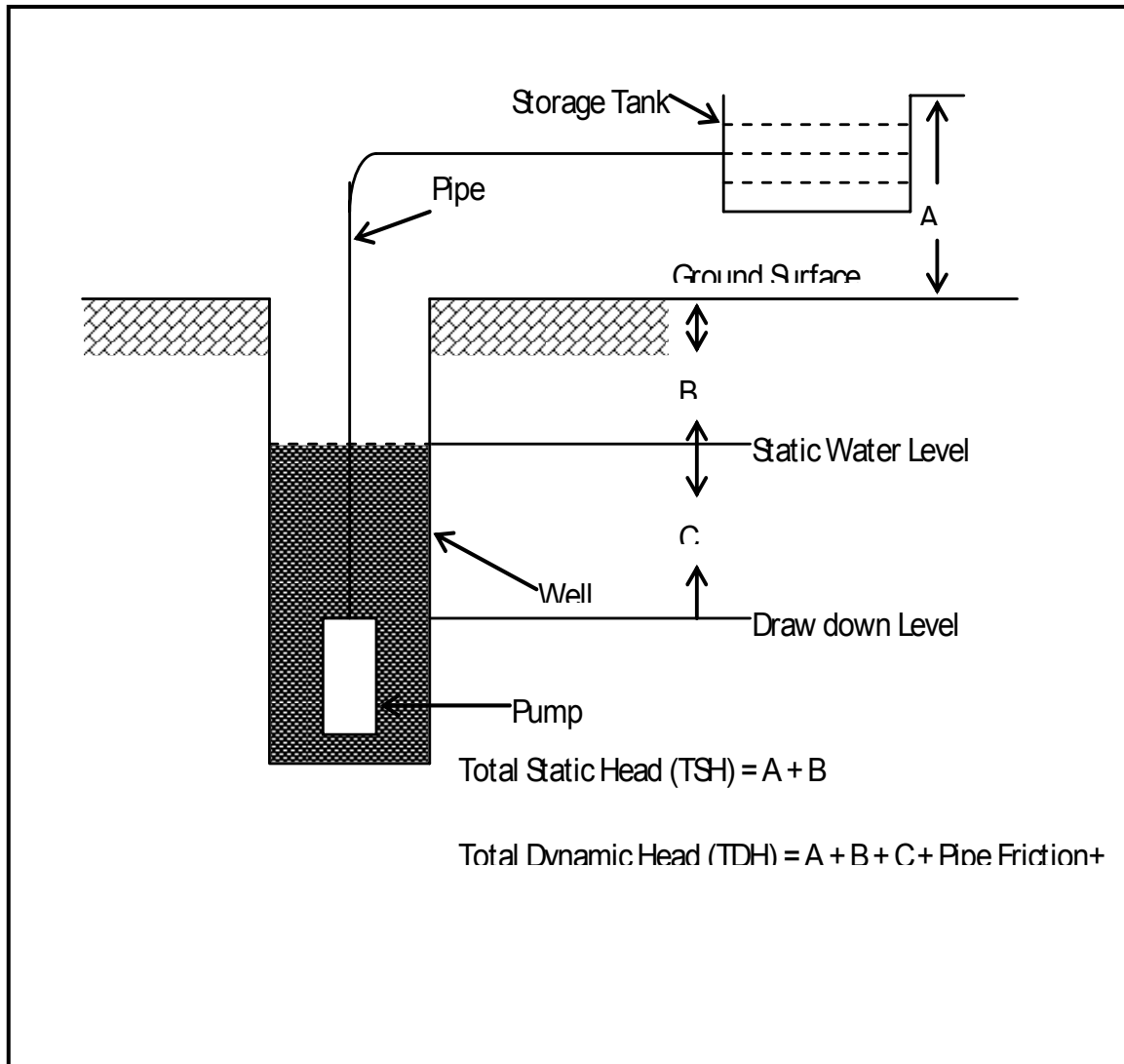
The general approach to designing a system can be summarized as follows:

**1. Determine the volume of water to be pumped each day,**

The volume of water to be pumped and over what period should be known. The volume to be pumped may vary significantly throughout the year and in fact may be entirely non-critical for some months of the year, as for some irrigation applications.

**2. Determine the total head**

The pumping head and its seasonal variations must be known and where



possible, information regarding water source replenishment rates should be obtained.

Total dynamic head = static head + friction loss + draw down as shown in figure above.

**3. Determine the solar insolation kWh/m<sup>2</sup>/day (minimum value should be selected for worst case)**

Any available insolation data should be obtained and (used in conjunction with the local conditions e.g. for determining the light intensity incident on the solar panels at certain angle during morning, noon or afternoon).

**4. Calculate the hydraulic energy in kWh/day needed to pump water at a volumetric rate V and total head h by using following formula.**

$$E_H = \rho V g H / \eta_p$$

Where:

V - total volume required per day

H - total dynamic head

$\rho$  - density of water, 1000kg/m<sup>3</sup>

g - acceleration due to gravity 9.81m/s<sup>2</sup>, and

$\eta_p$  - pump efficiency.

The pump efficiency  $\eta_p$  is a function of the load (head and flow-rate) and is available as a characteristic curve from the manufacturer. For general design purposes typical values given in table below may be used. The table lists two basic types of pumps, centrifugal and positive displacement. These pumps can be driven by AC or DC motors. DC motors are preferable for the PV applications, because they can be directly coupled to the PV array output. Centrifugal pumps with submersible motors are the optimum for PV applications because of their efficiency, reliability and economy. However, for deep wells Jack pumps may be necessary. Jack pumps are the piston type of positive displacement pumps that move chunks of water with each stroke. However they require very large currents, therefore they are connected through batteries.

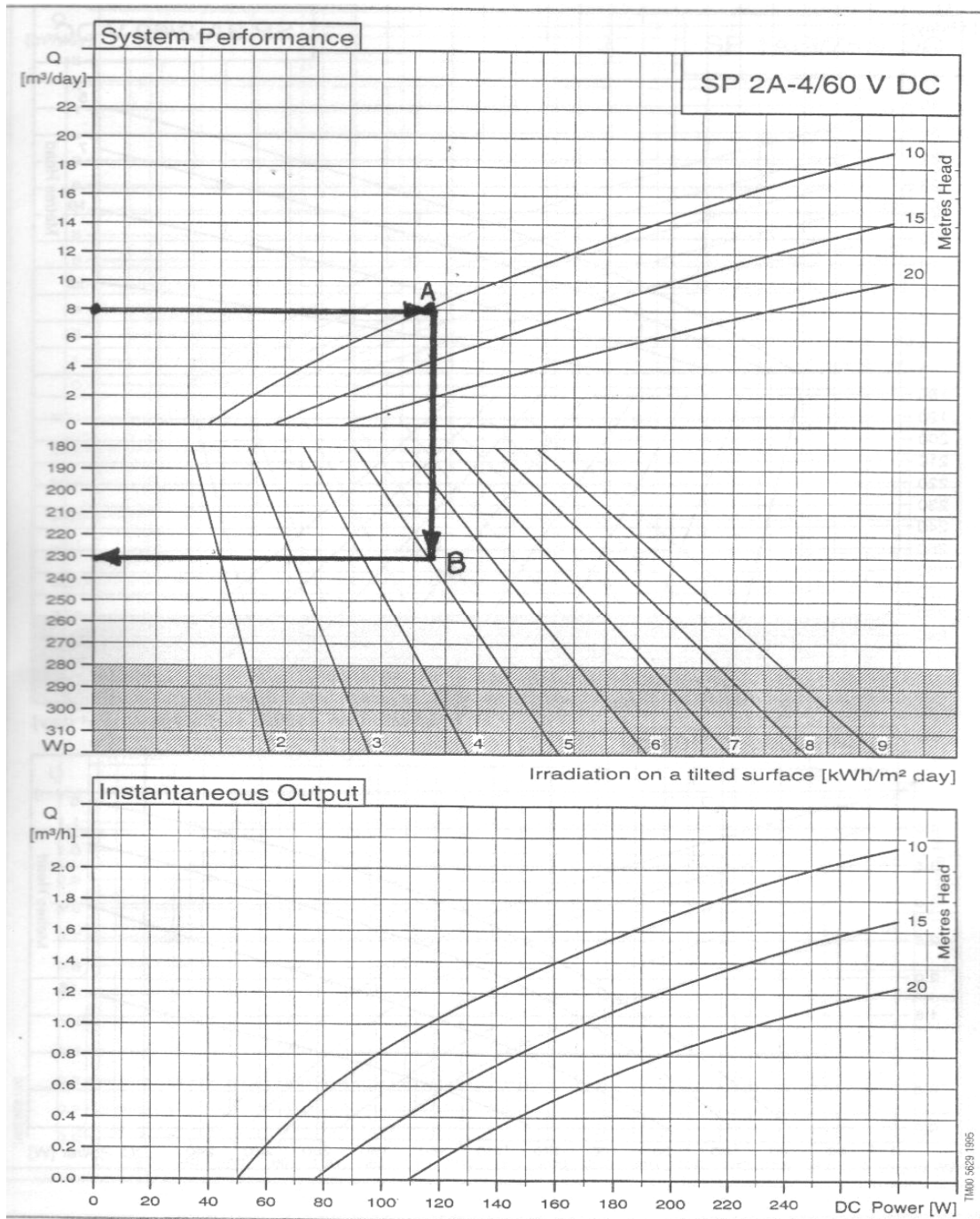
Head(m)	Pump Type	Wire to water efficiency (%)
0-5	Centrifugal	15-25
6-20	Centrifugal with Jet	10-20
	Submersible	20-30
21-100	Submersible	30-40
	Jack pump	30-45
>100	Jack pump	35-50

5. Select a pump to suit starting torque requirements, the range of operating heads, and physical dimension constraints imposed by the application

and one that will pump the required volume of water when operating at its maximum efficiency point. It is essential the torque / speed characteristics of the selected pump to be known, to facilitate system matching.

Most of the renowned and reliable pump manufacturers provided very reliable chart for the selection of appropriately rated motor/pump combination. The only input required is the yearly average peak sun for the given locality, daily water requirements ( $m^3$ ) and the total dynamic head. The manufacturers provide the system performance and instantaneous output graphs as illustrated in figure below.

Similar charts are available for pumps of various capacities meeting the daily water requirements and pumping head.



### System Performance and Instantaneous output chart

The steps in selecting appropriate pump would be as follows:

- consider the upper graph of the sample figure
  - draw a straight line from the point in m<sup>3</sup>/day axis until it intersects with the curve with the required head in meters
  - from the point of intersection A draw straight line down until it meets with the curve for given peak sun of the locality (intersection B)
  - Finally draw horizontal line from B to the Y axis with Wp indication. And the reading in this axis is the required array power in Wp.
6. **Select a motor with a torque / speed characteristic compatible with that of the pump. It is important that the motor operate near maximum efficiency when producing the necessary torque, to drive the pump at its design speed.**
  7. **Determine the temperature derating factor Ft**
  8. **Select mismatch factor between the array and pump Fm**
  9. **Determine the array size in kWp by using the following formula**

$$P = (E_H) / (S \times F_m \times F_t)$$

Where,

$E_H$  - Hydraulic Energy required in kWh / day

$S$  - Average daily solar insolation – peak sun in hours

$F_m$  - array / load matching factor, generally  $F_m = 0.8$

$F_t$  - temperature derating factor for array power loss due to heat; generally 0.8 for warm climate and 0.9 for cool climate.

#### 10. **Select appropriate solar panels**

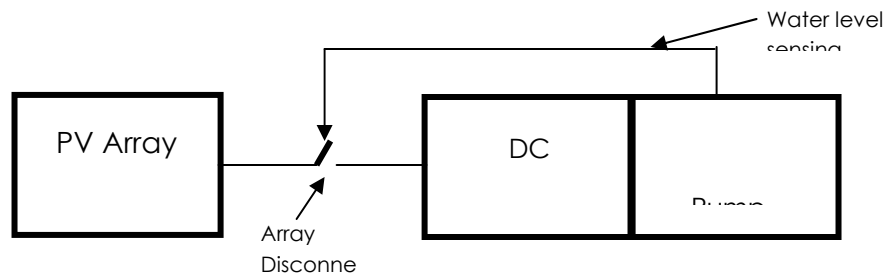
Appropriate sizing of the PV system will enable overall system specifications to be met, while simultaneously maximizing overall system efficiency. For this, both the

voltage and current at maximum power point need to be optimized. Standard commercial modules are normally designed for 12-volt systems (including considerable excess voltage capacity to allow for battery charging, regulation, blocking diode etc.) and can be connected in series to increase system voltage to multiples of 12 volt. In comparison, a reasonable choice in short circuit currents exists, due to the range of solar cell sizes and technologies used by different manufacturers.

11. Check the PV array power output and compare it with the pump selected.

## 12. Installation Line Diagrams

The suggested installation line diagram for various configurations is given in figure below.



Directly coupled DC motor/pump

**Annex 13 Format for Feasibility study of Solar Pumping Schemes**

**A. General Information:**

**A.1. Surveyor's Information:**

Name	Designation	Signature

**A.2. Date of Survey**

**A.3. End-Use Information**

Water Supply  Irrig

**A.4. Information about the Applicant CDC/Organization:**

Applicant CDC ID:

Name of CDC/or other organization:

.....

District:

.....

.....

Province.....

Name of CDC member contacted / interviewed:

Name	Designation	Signature


**B. Technical Feasibility Survey**

**B.1 General Information**

Location of the installation site:

CDC: .....Village.  
 .....

District.....Province.....  
 .....

Name of the nearest road head to installation site:  
 .....

Walking distance from the nearest road head to installation site: .....km

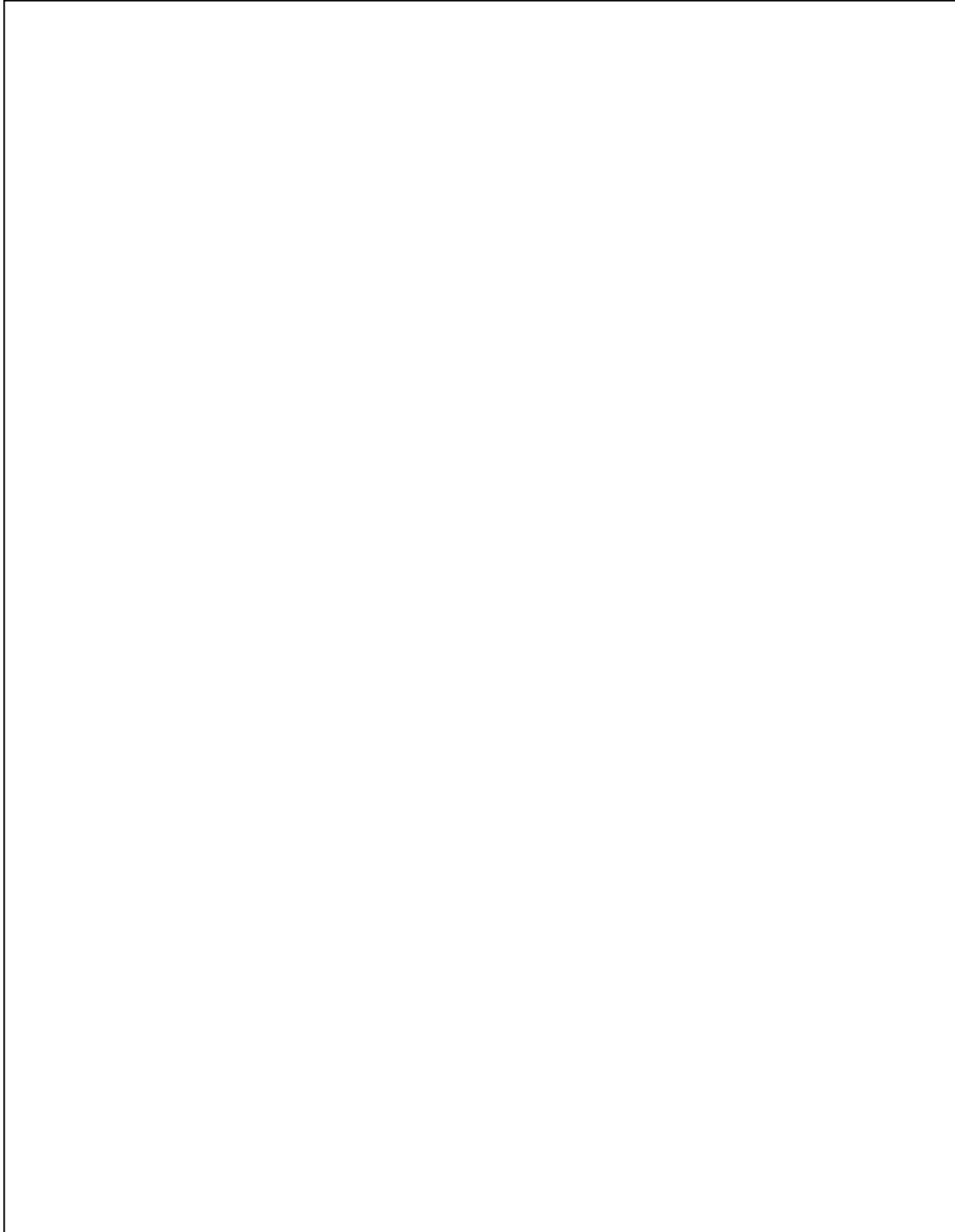
The distance from the national grid or micro hydro to the installation site:  
 .....km.

No. of beneficiary:                      Households Population

Expected no. of population in next 10 y                       Population

*(Make an estimate of the population growth for the next 10 years, which should be taken this into account for the system sizing. Cross-check the estimated value with regional population growth data;)*

**B.2 Sketch the map of proposed site**



**B.3. Technical Details:**

Name of water source: .....

Type of water resource: Spring  River

Others

Measured water flow (lps.): ..... Flow measured date:

.....

Type of water source: Seasonal  Perennial

Are there any other users of same source

If yes, please specify the water requirement by other users: ..... liter/day

If the source is underground, assess the ground water recharge

Pipe length in m:

*( The pipe length from pump to distribution tank should be estimated taking into account that the shortest route might not be the most feasible one)*

Cable length in m

Total length of distribution pipe in

Highest temperature in site  (summer)

Lowest temperature in site  (winter)

Demand of water per HH/ d  ltrs

Total water requirement per day  ltrs.

Total head available in

Design head in m

Number of cloudy days / year

Average number of sunny hours/day: Summer  Winter

Present the daily means to monthly global horizontal solar radiation from a nearby meteorological station

Average peak sun per day in hour

Is the site selected for installation of PV array safe enough? If not, specify what could be the possible natural calamities on the specified site:

(Also include a risk estimate for possible theft of the panel or pump.)

.....  
.....  
.....  
.....  
.....

**B.4. Local Rates in Project Area**

Description	Unit	Rate / unit	Comments
Sand	M3		
Stone	M3		
Coarse aggregates	M3		
Wood for mounting structure	M3		
Unskilled labour	Md		
Mason	Md		
Carpenter	Md		
Cement	Bag		

**C. Surveyor's Conclusion:**

The demand is technically: Feas  Not

If the project is feasible

Total design size of the demanded project: ..... KWp

If the demand is not feasible, then reasons for non-feasibility:

- 1.....
- 2.....
- 3.....
- 4.....
- 5.....

### Annex 14 Feasibility Survey Form for Household Biogas Plant

(Please use  $\surd$  marks where applicable)

1. Name of Owner: \_\_\_\_\_

2. Address: Province .....District .....Village  
\_\_\_\_\_

3. Geographical Location: N: \_\_\_\_\_.\_\_\_\_\_ E: \_\_\_\_\_.\_\_\_\_\_ Elevation:\_\_\_\_\_ m

6. Family size:

a. Male:

b. Female:

7. Is toilet connected to house?

a. Yes

b. No

8. Total No. of Toilet Users:

9. No of cattle

Cow  Buffalo  Goat  Chicken

10. Water Source/ Distance  minutes walk one way &  minutes in Dry season

a. Hand Pump  b. well  c. RIVER  d.   
 Others  
 e. Water table (m)

11. Fuels Used for Cooking Food

	Daily	Monthly	Avg: Expenses/month
a. Electricity (kWh)	<input type="text"/>	<input type="text"/>	<input type="text"/>
b. LPG Gas (Kg)	<input type="text"/>	<input type="text"/>	<input type="text"/>
c. Kerosene (Liters)	<input type="text"/>	<input type="text"/>	<input type="text"/>
d. Wood (Kg)	<input type="text"/>	<input type="text"/>	<input type="text"/>
	<input type="text"/>	<input type="text"/>	<input type="text"/>

e. Other Fuels

12. Outside temperature lowest  highest

13. Distance from the plant to kitchen

14. Sun shine hours per day

15. Number of bulbs and time required for lighting

16. Cooking hour per day

17. Quantity of Biodegradable Waste Produced daily (Kg/day)

a. Kitchen Waste

b. Bio-degradable Waste

c. Quantity of dry dung available (kg).

18. How are you managing the produced bio-degradable waste at present?

a. Simply dumping at a place within the household

b. Dumping at garden/farm field through the collector

c. Making compost

d. Others

**19. Interest of Building a Biogas Plant**

- a. Highly interested
- b. interested
- c. Not Interested

**20. Why you are interested to install a bio-digester?**

.....

.....

.....

.....

**21. Are you ready to collect local construction material (sand, stone,) in constructing a Biogas Plant?**

- a. Yes
- b. No

**22. What is / are your expectation (s) ?**

.....

.....

.....

.....

Name of the House owner:.....

Signature.....

Date:...../...../ 2008

Name of the Interviewer:.....

Signature.....

NB: Special observations by the Interviewer

.....  
.....  
.....  
.....  
.....  
.....

Sketch of Location: (*Kitchen, Water Source, Toilets and sufficient space for compost pits etc*)

### *Fixed Dome, Biogas Plant (Source- BSP Nepal)*

#### Plant Feeding, Gas Production & Stove Burning Hours

Plant Size M3	Initial Dung Feed, kg	Daily Dung Feed, Kg (@6-7.5 Kg Dung/M3 Size)	No. of Cow Required (@12 Kg Dung/Cow)	Daily Water Feed, Litres	Daily Gas Produced, Lt. (@40 Lt./Kg Dung)	Daily Stove Burning Hrs. (@400Lit/Hr)
4	2,025	24-30	2-3	24-30	960	2:24
6	2,900	36-45	3-4	36-45	1,440	3:36
8	3,930	48-60	4-5	48-60	1,920	4:48
10	4,490	60-75	5-6	60-75	2,400	6:00

#### Design parameter for Sizing Biogas Plants

Retention time - 40-100 days

Digestion temperature- 20-35

PH 6-7

C/N ratio- 20-30

Biogas energy content- 6kwh/m<sup>3</sup>

Gas production per kg of cow dung - 0.023-0.04 m<sup>3</sup>

Gas production per kg of chicken dung- 0.065-0.0116 m<sup>3</sup>

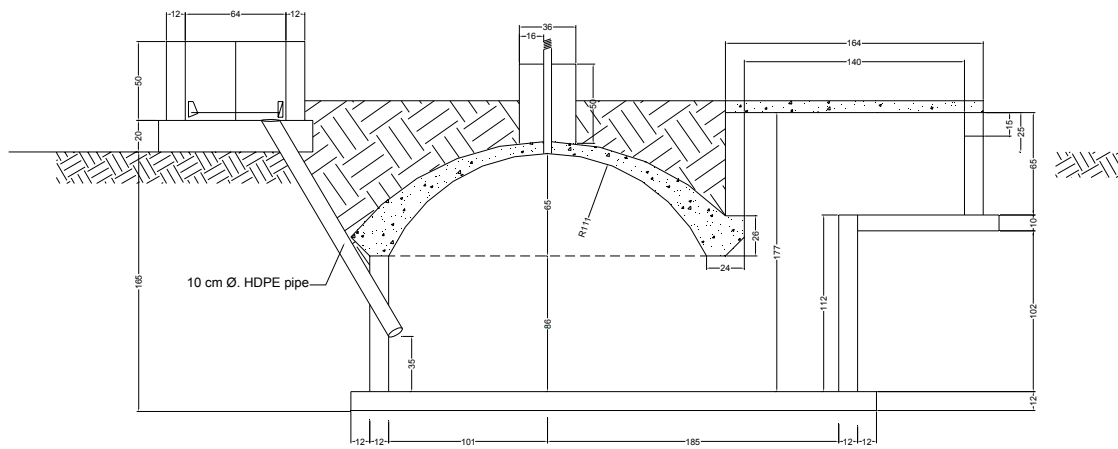
Gas production per kg of human excreta- 0.020-0.028m<sup>3</sup>

Gas requirement for cooking- 0.2-0.3 m<sup>3</sup>/person

Gas requirement for lighting one lamp - 0.1-0.15 m<sup>3</sup>/hr

**Quantity of main construction materials:**

Plant Size M3	No. of Cement bag (@50kg/bag)	Stone quantity, (Or Bricks, Number) M3	Gravel in No. of Cement Bag	Sand in No. of Cement Bag	Paint, in Litre
4	11-12	3.5 (1,200)	30	60	1.0
6	13-14	4.5 (1,400)	35	70	1.0
8	15-16	6.5 (1,700)	40	80	1.5
10	19-21	8.0 (2,000)	50	90	2.0



## Annex 15 Capacity Development Activities

Institution	Roles & Responsibilities	Capacity Dev. Activities
<i>Central Level</i>		
MRRD, MEW, Ministry of Planning, Ministry of Finance, Ministry of Industry, Directorate of Environmental Protection	Energy & Environment Policy	<ul style="list-style-type: none"> <li>• Orientation on renewable energy, environment, Climate Change, Kyoto Protocol, CDM</li> </ul>
MRRD/RLED	Energy Planning & Policy	<ul style="list-style-type: none"> <li>• Orientation on renewable energy, energy planning, environment, gender sensitization.</li> <li>• Orientation on Climate Change, Kyoto Protocol, CDM</li> <li>• Exposure visit to Nepal</li> </ul>
RITS	Engineering Services/Standardization	<ul style="list-style-type: none"> <li>• Technical Training</li> <li>• EIA</li> <li>• Gender sensitization</li> <li>• Exposure visit to Nepal</li> </ul>
Private Sector	Survey, Design, Supply, Installation, After-sales Services	<ul style="list-style-type: none"> <li>• Training on Manufacturing, Installation, Feasibility Studies</li> <li>• EIA</li> <li>• Follow-up training</li> </ul>
Financial Institutions	Loan/Subsidy Channeling	<ul style="list-style-type: none"> <li>• Orientation</li> <li>• Exposure Visits</li> </ul>
<i>Provincial Level</i>		
Provincial Government	Coordination/Monitoring Energy Planning	<ul style="list-style-type: none"> <li>• Orientation on renewable energy, energy planning, gender sensitization, environment</li> <li>• Exposure visit</li> </ul>
PRRD	Energy Planning Survey/Monitoring	<ul style="list-style-type: none"> <li>• Technical Training</li> <li>• Energy planning</li> <li>• EIA</li> <li>• Gender sensitization</li> <li>• Exposure visit</li> </ul>

<i>District Level</i>		
DDA	Energy Planning	<ul style="list-style-type: none"> <li>• Orientation on renewable energy, environment, gender sensitization</li> <li>• Workshop on Energy Planning</li> </ul>
Energy Unit in DDA	Technical/Management Services Energy Planning	<ul style="list-style-type: none"> <li>• Technical Training</li> <li>• EIA</li> <li>• Gender sensitization</li> <li>• Exposure visit</li> </ul>
Support Organization	Community Mobilization Survey/Design End-uses promotion	<ul style="list-style-type: none"> <li>• Training on CM</li> <li>• Technical Training</li> <li>• Management Training</li> <li>• Gender Sensitization</li> <li>• EIA</li> <li>• Orientation on end-uses</li> <li>• Business plan preparation</li> <li>• Exposure visit</li> <li>• Follow-up Training</li> </ul>
Rural Energy Service Center	Survey/Design Installation, Repair & Maintenance End-uses promotion	<ul style="list-style-type: none"> <li>• Technical Training</li> <li>• EIA</li> <li>• Gender sensitization</li> <li>• Hands-on installation</li> <li>• Follow-up Training</li> <li>• Orientation on end-uses</li> </ul>
<b>Community Level</b>		
Community	Sustainable management of energy systems	<ul style="list-style-type: none"> <li>• Orientation on CM</li> <li>• Management Training</li> <li>• Literacy Classes</li> <li>• Exposure visits</li> <li>• Electricity use &amp; safety</li> <li>• Orientation on end-uses</li> <li>• Follow-up Trainings</li> </ul>
Functional Group	Regular Operation & Management End-uses promotion	<ul style="list-style-type: none"> <li>• Operation &amp; Maintenance</li> <li>• Management Trainings</li> <li>• Hands-on Installation</li> <li>• Orientation on end-</li> </ul>

		uses • Business plan preparation • Follow-up trainings
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## تکنا لوژی انرژی روستائی

آب، آفتاب، باد و مواد اضافی حیوانی و نباتی از جمله منابع انرژی قابل تجدید می باشد.

این منابع دوامدار و لایتنهای می باشد، در صورتیکه از این منابع استفاده نمایم از آلوده گی محیط زیست کاسته می شود، استخراج این منابع تأثیر منفی بالای محیط زیست ندارد. انسانها از زمان قدیم از این منابع استفاده می نمودند، تکنا لوژی ساده و عصری باعث شد تا مؤثریت و ظرفیت آن بهبودیابند.

یک تعداد محدود از این تکنالوژی ذیلا توضیح میشود.

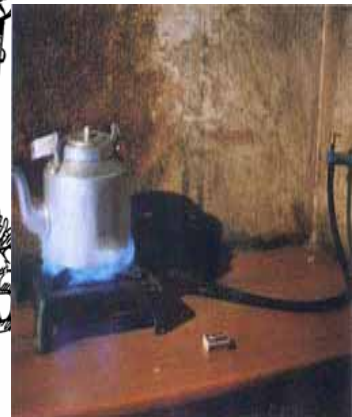
### دیگدانهای اصلاح شده پخت و پز

دود کم دارد یا هیچ ندارد و به مقایسه دیگدانهای عادی حرارت زیاد تولید میکند و مؤثریت زیاد دارد، قیمت آن کم است در روستاها ساختن آن آسان است و از مواد محلی ساخته می شود. تأثیرات مثبت آن برای اعضای فامیلها زیاد است خصوصاً برای طبقه انان، نظربه دیگدانهای عادی برای پخت و پز مصرف مواد احتراقی آن کم است.

### بیوگاز

مواد فاضله حیوانی و انسانی برای تولید گاز استفاده میشود. گاز تولید شده برای پخت و پز و روشنائی استفاده شده میتواند.

قیمت نصب یک دستگاه بیوگاز از 60000 افغانی الی 80000 افغانی نظر به حجم و موقعیت جای آن فرق میکند. این دستگاه قادر خواهد بود تا سه هفته پخت و پز یک فامیل با روشنی چراغ آن در شب تامین نمایند.



## آسیاب اصلاح شده آبی

بخاطر ازدیاد ظرفیت آسیاب عنعنوی پرهای آهنی عوض پره های چوبی نصب مینمایم. در آسیاب اصلاح شده جنراتور را نصب می توانیم تا مطابق توان خود برق تولید نماید.

قیمت نصب یک آسیاب از 35000 افغانی الی 60000 افغانی میباشد و مبلغ اضافی افغانی ضرورت است تا مقدار 1.5 کیلو وات جنراتور نصب و برق استخراج نمایم.



## برق آبی کوچک



تا 100 کیلو وات برق توسط دستگاه کوچک آبی تولید شده میتواند، آب از دریا مسیر داده می شود در کانال به فریبی رسانده شود، از آن جا توسط ناوه یا پیپ به توربین رسانده می شود، آب با داشتن سرعت زیاد توربین را میچرخاند و به انرژی میخانیکی تبدیل میگردد، این توان میخانیکی بخاطر چرخاندن آسیاب آرد و یا چرخاندن جنراتور استفاده می شود تا برق تولید نماید. قیمت تولید برق در یک کیلو وات از 100000 افغانی الی 150000 افغانی میشود. البته تنها تهیه برق

قیمت ساختمانی و انتقال لین در آن شامل نمی باشد.

## دیگ آفتابی



اشعه آفتاب توسط انعکاس در یک بکس جمع شده قسمی که بکس خود سیاه رنگ شده و برای جذب حرارت مناسب می باشد بنا زود تر می پزد، نمی سوزاند، ضرورت به واری ندارد. قیمت یک پایه دیگ آفتابی در حدود 7500 افغانی میباشد.

## آب گرم کن آفتابی



جمع کننده سیاه رنگ و پیپ سیاه رنگ حرارت را جذب نموده و آب که در پیپ است گرم شده در نتیجه بالا می‌رود و آب سرد از پایین تانک جای آنرا می‌گیرد، قیمت یک پایه آب گرم کن آفتابی در حدود 25000 افغانی می‌باشد، ساخت وطن مبلغ 12000 افغانی خواهد شد.

## خشک کن آفتابی

توسط اشعه آفتابی کالا میوه جات و سبزیجات را خشک می نماید. بکس که مجرای دخول آن در زیر و خروج هوا در سر قرار دارد، کالا میوه جات را در داخل آن مانده و بکس را در هوا آزاد مقابل اشعه آفتاب قرار می دهیم. قیمت تهیه خشک کن آفتابی 14000 افغانی می باشد.



## برق آفتابی

انرژی آفتابی به برق توسط سیل فوتوولتک تبدیل می شود. برق تولید شده در بطری ذخیره می شود هرگاه ضرورت باشد از آن استفاده صورت می گیرد. قیمت برق تولید شده فی وات مبلغ 300 افغانی الی 375 افغانی نظر به ظرفیت و موقعیت آن می باشد.

این تکنالوجی در مناطق که برق آبی ممکن نباشد زیاد موثر است



## نرژي بادي



این تکنالوژی در مناطق قابل استفاده است که باد دوامدار و زیاد داشته باشد، باد قوی پرهای ماشین را بگردش می آورد، که از اثر گردش ماشین برق تولید میشود برق را همزمان استفاده میتوانیم و یا آنرا در بطری ذخیره میکنیم همچنان برای پمپ نمودن آب برای زراعت نیز استفاده میشود.

قیمت آسیاب بادی که یک کیلو وات برق تولید نماید 250000 افغانی می باشد و مبلغ افغانی قیمت واتر پمپ آن می شود.

## ده مشکل عمده برای انسان هادر پنجاه سال آینده



1: انرژي

2: آب

3: غذا

4: محیط زیست

5: غربت

6: جنگ و تروریزم

7: امراض

8: دیموکراسی

9: تعلیم و تربیه

10: نفوس

## Annex 17 MRRD Micro Hydro Policy (Draft)

### 1. Background

Afghanistan has one of the lowest per capita commercial energy consumption in the world. Only about 25% of the population has access to electricity - in rural areas, less than 14% of the population has access to electricity. Most of the rural population depends on animal waste and agricultural residues for their cooking and heating needs and kerosene for lighting. Many years of political instability and conflict has severely hampered rural development including the energy sector in Afghanistan.

The Afghanistan Compact envisages providing electricity to at least 25% of the rural population by 2010.. It is well recognized that the traditional method of providing electricity by extending the national grid fed by large hydropower stations is not a realistic option to meet this goal as it is both capital intensive and takes a long time to complete. In this context, Afghanistan National Development Strategy (ANDS) has given MRRD the main role for promotion of the rural energy sector in the country.

There are sufficient renewable energy resources in Afghanistan that can be utilized to meet the demands for electricity in rural areas for the near future. Although Micro hydropower is the most developed sector in the country among all renewable resources through National Solidarity Program (NSP), there is no uniform microhydro policy in MRRD. This MRRD Micro Hydropower Development Policy has been prepared based on the NSP experience supplemented by the successful cases from the neighboring countries – particularly Nepal, which is well recognized for the development of the micro hydropower sub-sector. Furthermore, this policy intent has been informed by the feedbacks from various stakeholders who participated in the 1<sup>st</sup> Rural Energy Consultative Meeting organized by ERDA/NABDP/MRRD, MRRD's Strategic Intent and ANDS.

It is envisaged that the MRRD Micro Hydropower Development Policy will be the foundation on which MRRD Rural Energy Policy will be developed and later Rural Energy Policy for Afghanistan.

### 2. Objectives

1. To provide rural Afghanistan with a reliable and affordable source of electricity.
2. To make multiple uses of local water resources for water supply, irrigation and power generation.
3. To support economic development of rural Afghanistan through promotion of electricity driven micro industries.
4. To develop and lay the foundations for an Afghan hydropower industry that will eventually be capable of designing, building and managing larger hydropower.

5. To increase the involvement of user-groups, non-government organizations (NGOs), cooperatives and private sector in the development of microhydro.

### **3. Basic Principles**

Micro hydropower will be developed on the basic principle of local construction, local finance, local management and local consumption.

Local construction- In so far as it is practicable as much of the work will be done at the village level, then moving on to the provincial and national level when the appropriate skills and material are not available at these levels. As far as it is practical, efforts will be made to make the products or services available in Afghanistan. By and large we should be able to say that the MHP project is "Made in Afghanistan".

Local finance - At the initial stages, MHP projects will be developed largely through subsidy from donors but as the economic condition of the country improves resource will be mobilized internally by taxing fossil fuels. Moreover, local communities and private entrepreneurs will also shoulder proportion of the total project costs. The beneficiary community will contribute at least 10% of the total project cost for MHP largely in the form of voluntary labor.

Local management- The management of the MHPs will be done by the people at the community level. The government will support in enhancing capabilities of local people to operate and manage MHP.

Local consumption- Access to electricity is not by itself sufficient to achieve economic development. The power from the MHP must be utilized for productive economic activity in order to achieve economic development in rural areas. Local communities will be assisted in using the output to the greatest possible extent. Electricity using micro industries will be promoted in the rural areas.

The MHP are a source of income for local communities and also represent a considerable investment. Therefore, as the national grid is extended to areas which have MHP, the MHP will be connected to the grid and power exchanged with the grid on an equitable basis. This will provide the local community with an additional source of income and energy and build a firm foundation for rural development in Afghanistan.

### **4. MRRD's Jurisdiction**

The ANDS gives MRRD jurisdiction over rural remote energy. It defines rural remote areas as settlements with less than 5000 inhabitants and at a reasonable distance from the electricity grid as well as urban and peri-urban areas and areas that will not be covered by MOEW. This restricts MRRD from working in a large part of the rural areas. On the other hand, MOEW does not have resources and outreach to cover these areas. An amendment on ANDS is required to lift the restriction imposed on MRRD's jurisdiction.

Furthermore, at the moment the upper limit of micro hydropower is set at 100 kW. This is due to current limitations in the technology and products currently available in the Afghan market. As the locally available MHP technology and products improve, this limitation will be raised in order to allow the local technology to expand their range of operation. The maximum upper limit is taken as 1000 kW. Currently, higher outputs are covered by the Ministry of Energy and Water and the range from 100 to 1000 kW is not adequately covered. Having the upper limit at 1000 kW will provide the space for local technology to develop.

In this context, given the experience of MRRD and the limited outreach of MOEW, limitation on MRRD's jurisdiction should be limited to isolated hydropower plants and related electricity distribution networks of 1 MW capacity and not included in MOEW's 5 years' plans. The main aim is to provide electricity to as many Afghans as soon as possible and use all the resources at hand to realize the goal of Afghanistan Compact.

## 5. Policies

The main objective of promoting micro hydropower in Afghanistan is to enhance rural livelihoods by providing access to electricity, employment creation through productive use of electricity and multiple uses of local water resources, and protection and preservation of the natural environment. In order to achieve the objectives in line with the principles set out above the following policies will be adopted:

- 5.1. Community Mobilization – MRRD will support community mobilization activities to help CDC and CCDC to form Micro Hydro Functional Group to undertake development and sustainable operation and management of MHP as profit making enterprise and to ensure equitable and inclusive rural development by involving all economic, ethnic and gender groups.
- 5.2. Technology- Local companies are producing turbines and accessories for Micro hydropower technology. Micro hydropower technology will be developed, adopted, researched, and licensed as required. Support will be provided to private sector workshop to produce efficient and reliable equipment within Afghanistan. Research and field testing and adaptation tests of innovative technologies will be encouraged. The main areas of technology development are survey, design, construction, electro-mechanical equipment, operation and maintenance and productive use of electricity.

- 5.3. Subsidy and Grants - MHPs are highly dependent on grant from the government and donor. Given the economic status of the rural areas, subsidy/grant has to continue for the foreseeable future. MRRD will provide grant amounting to the maximum of 90% of the total project cost to the CDC or CCDC for establishment of MHP. The beneficiary community will contribute at least 10% (cost for local material and unskilled labour) of the total project cost either in cash or kinds or both. MRRD will also provide a grant of \$200/kW for promotion of productive use of electricity. Furthermore, MRRD will also provide financial grant for training for 3 operators & a manager, research and development and institutionalization of MH related training. The basic principle is to provide financial support to the economically deprived communities in rural areas to install MHP but discourage any subsidy for operation and management. Grant/subsidy for solar home systems will be discouraged in areas with technically and financially viable potential for MHP and having plans to develop it in near future. In case of extending wire is expensive, solar home system is an alternative.
- 5.4. Rural Energy Master Plan: MRRD will prepare a master plan for development of rural energy including hydropower for the entire country. The master plan will assess the status of energy production and consumption in the rural areas, the energy needs of the rural population and the rural/renewable energy resources available and identify the most cost effective energy option and prepare a plan to provide energy to the rural population within a given timeframe, formulate strategies that will be used to achieve the goal and the required resources. In this regard, MRRD will develop a GIS system to identify potential micro and mini hydropower sites in Afghanistan. This will help in identifying best sites from desk study and the field study could be made more targeted and cost effective.
- 5.5. Rural Energy Development Fund (REDF) will be established within MRRD to mobilize internal as well as external resources. Rural Energy and Enterprise Department (REED) will administer the fund. Ultimately, the Fund will become an autonomous body. In the beginning donor grants will be mobilized to support development of MHP but gradually internal resources will also be mobilized. Rural/renewable energy will be promoted by taxing imported fossil fuels. MRRD will also proactively engage in mobilizing resources from Clean Development Mechanism for promotion of clean energy technologies. It will coordinate with other ministries and line agencies to encourage the Government of Afghanistan to sign the Kyoto Protocol and take all necessary steps to mobilize resources from CDM to promote rural energy including MHP.
- 5.6. Private sector- Private sector workshops are mainly involved in fabrication of turbine and accessories, supply of electro-mechanical equipment and installation. They also provide training for plant operators. Involvement of the private sector in MHP will be encouraged and supported in order to enable them to meet the objectives set in this policy. Private workshop at the provincial/regional levels will be supported to establish Rural Energy Service Center to provide repair and maintenance services to MHP and other rural energy systems. Rural entrepreneurs will be supported to install and operate MHP as well as productive end-uses of

electricity. Even community owned and managed plants will be encouraged to operate in profit making basis so that surplus resource is available to undertake major repair and maintenance activities when necessary.

- 5.7. Capacity building- In order to achieve the objectives a lot of skilled and professional manpower is required. MRRD will develop the necessary skill base to achieve the objectives. This will include, but not be limited to building up the capacity of the communities to operate, manage and utilize the MHPs; to private sector engineering companies and PRRD to survey, design and provide technical backstopping; to workshops manufacturers to design, manufacture and install the electromechanical components of MHPs; to educational and professional institutions to educate and train the manpower required for MHP and to institutionalize training program. Likewise, MRRD will support in preparation of guidelines and manuals to carry out various activities related to MHP development.
- 5.8. Tariff Setting: The owner will have full authority to set electricity tariff in isolated MHP. Operation and Maintenance costs and depreciation will be considered and the beneficiaries consulted in fixing tariff rates.
- 5.9. Standards and standardization- In order to reduce costs and speed up the process of implementing MHP projects the MHP technology and equipment will be standardized as far as is practicable. National MHP standards will be developed in order to maintain and improve the quality and cost of MHPs. Furthermore, to ensure quality products and services, MRRD will pre-qualify contractors, suppliers and manufacturers of MHP components and equipment and regularly update.

MRRD will also develop its implementation modalities that will be followed by all projects and departments involved in promotion of MHP in the country.

- 5.10. Relations with other institutions- MRRD will encourage and when necessary take the lead in establishing relations with institutions in order to meet the objectives. These include national and international institutions, governments and semi-government bodies. MRRD will work through the existing Inter-Ministerial Coordination Committee on Hydropower and Inter-Ministerial Commission on Energy (ICE) to coordinate its activities with other ministries, particularly Ministry of Energy and Water. MRRD will work to become a core member of ICE from current ad hoc member status and establish a committee for coordinating activities related to rural energy.
- 5.11. Water Mills – There are thousands of traditional water mills all over Afghanistan. These mills provide grinding services to the village people. MRRD will work towards transferring technologies from abroad to improve these water mills to generate electricity and the millers will be supported to smoothly operate the improved systems. MRRD will provide grants to those millers who agree to improve their mills and supply electricity to villagers. In the beginning this program will be launched as a pilot project.

- 5.12. Rehabilitation of non-operational plant: MRRD will assess the performance of MHP installed in past to identify major problems. Lessons learnt will be incorporated in policies and implementation modalities.  
Furthermore, MRRD will support the MHP that are not in operation or are operating at very low efficiency. MRRD will provide both technical assistance and limited amount of financial support to revive/upgrade these plants.
- 5.13. Innovation – MRRD will support the communities, private sector, non-governmental sector, education institutions, civic society, rural entrepreneurs, etc. to try and test innovative ideas and technologies related to MHP. In this regard, MRRD is implementing Energy for Rural Development Afghanistan (ERDA) to try best practices from the region for sustainable operation and management of renewable energy systems. It is envisaged that the 'ERDA model' will pave way for establishing the 'MRRD Model' for MHP as well as other rural energy systems.
- 5.14. Rural Energy Unit – MRRD will establish Rural Energy Unit within REED that will be responsible for implementing microhydro projects including undertaking innovations related MHP and other renewable energy technologies. REU will also focus on field-testing and adaptive research and identifying best modalities for Afghanistan. It will coordinate its activities with Renewable Energy Center of MOEW.
- 5.15. Registration of Water Uses: MRRD in consultation with MOEW, Ministry of Agriculture, etc. will initiate provision of registering water uses including power generation with the DDA to avoid water uses conflicts in future.
- 5.16. Legislation- In case there are legislative impediments to achieving the objectives MRRD will take the obstacles. In case new legislation is required or amendments need to be made to existing legislation MRRD will take the initiative in amending or enacting the legislation.

## **6. Institutional Arrangement & Implementation Modality**

- 6.1. At the central level Rural Energy and Enterprise Department will be the focal body for promoting micro hydro related activities of MRRD. A coordinating body led by REED Director and with representation from NSP, RITS and ERDA will be established to streamline implementation approaches and also to coordinate activities.
- 6.2. A committee will be established at the provincial level with representation from PRRD, NSP, NABDP provincial offices to coordinate activities at that level.
- 6.3. DDA and the Facilitating Partners of NSP will be responsible for facilitating the communities and providing technical backstopping. REED will support DDA to provide technical backstopping during the construction period.
- 6.4. MRRD will provide grant to the CDC or CCDC depending on the project size and beneficiary distribution. The beneficiaries will be responsible for providing at least 10% of the total project cost. The CDC or CCDC will be the owner of the MHP and will be responsible for installation and operation. The CDC with the written consent of all beneficiaries can choose the implementation and management mechanism that could include CDC, CCDC, DDA, group of beneficiaries, cooperative,

traditional organizations or individual entrepreneurs or a group of entrepreneurs etc. CDC/CCDC has to get approval from MRRD for the type of management they opt for.

- 6.5. The CDC/CCDC will sign a contract with MRRD pre-qualified company for the supply and installation of electromechanical equipment and distribution network. MRRD through DDA will provide technical assistance for supervision of civil works.

