Final Report

Sustainability Assessment of Micro and Mini Hydro Power Plants with a Generation Capacity of 5 to 500 kW in Badakhshan, Afghanistan

Presented to

Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH
65726 Eschborn
Deutschland/Germany

Prepared by

EssenceDirect GmbH
Dr. Thomas Meier
Lättenstrasse 2
CH-8185 Winkel
tmeier@essencedirect.ch

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Picture on Title page: Villagers from Obast in Darwaz e Bala present their MHP (No. 1012)

1 INTRODUCTION

1.1 Background of the IDEA program

The Ministry of Energy and Water (MEW) is the responsible Ministry for the development of the energy sector in Afghanistan. MEW designs policies, strategies and sector plans and facilitates governmental decision-making processes. Additionally, MEW encourages the implementation of policies and strategies by public and private stakeholders in order to match the growing energy demand of population, industry, commerce and transport.

The Afghan-German technical cooperation program "Institutional Development for Energy in Afghanistan (IDEA)" is strengthening the key public institutions of the energy sector (MEW, DABS, and MRRD). IDEA intends to link the micro, meso and macro level, promote awareness of renewable energy and energy efficiency and enable private investment into the energy sector.

1.2 Background of this assessment

Appropriate maintenance of hydro and solar power plants is essential to maximize the lifetime and optimize energy yields, serving energy availability and security. Poor maintenance on the other hand, increases project costs due to more frequent operation failure. This concern is especially pressing in rural areas due to limited and costly access to spare parts and repair services.

International experience shows that the sustainable operation MHP as well as rural infrastructure in general, is challenging, in particular if the infrastructure is community operated. In many cases MHPs are facing operational difficulties within a short period after commissioning. One reason may be improper Operation and Maintenance (O&M) caused by a lack of knowledge and awareness. However, numerous other factors (economic, social, environmental and security) contribute to a sustainable operation of a rural power scheme particularly in a destabilized context like Afghanistan. These factors have not yet been systematically assessed.

1.3 Objective

To objective of this assignment was to better understand the situation of MHP plants in Afghanistan. For this purpose, GIZ commissioned a comprehensive survey of 600 MHPs in Badakhshan province in 2017. The survey results presented in this report constitute the scientific basis to develop a Sustainability Plan for Micro and Mini hydropower (MHP) projects with a generation capacity of 5 to 500 kW.

The author was contracted by GIZ as international study coordinator leading a local data collection team of 25 people.

1.4 Scope of survey and methodology

Based on various databases obtained from MEW, MRRD, GIZ, Aga Khan Foundation and other NGOs, 845 MHPs were identified in Badakhshan. The idea was to visit around 600 MHPs which were selected based on the capacity range (5 to 500kW) and security concerns. The data collection was done based on a Sustainability Assessment Tool (SAT) developed by the author of this study. It is a structured questionnaire containing a scoring system based on the five sustainability factors:

1. Planning and Design of MHPS
2. Quality of construction and components
3. Management, Maintenance, and Repairs
4. Natural Disaster Risks
5. Electricity use and Profitability

The Excel-based questionnaire contained macros (visual basic element) which allowed directly uploading the data into the survey database. This database was used for the statistical analysis.

For the data collection, a national contractor was contracted. The author prepared RfP and ToR documents and GIZ formally published a tender. The selected contractor was QADERDAN RURAL TECHNOLOGY DEVELOPMENT WORKSHOP, a national company that has own experience in MHP development in Badakhshan. The contractor established a team of 20 Enumerators divided into four group each led by a national Study Group Leader. The whole team was led by a National Study Coordinator.

The SAT tool was intensively discussed with GIZ and the contractor. Due to the tight security situation it was not possible for the author to conduct a training for the data collection team in Afghanistan. Instead several Skype conferences were conducted. After initial field tests, the data collection team reported their experiences based on which the SAT was revised again. The official data collection was conducted from November 4 to December 17, 2017 during which 602 MHPs were surveyed.

In 65% of all interviews the main respondent of the SAT was the head of the MHP management committee. In 19% interviews were conducted with the operator, and in 10% a group interview with members of the management committee was conducted (0-10).

The process of transcribing the data from Dari into English and uploading the data into the database was completed in the first week of January 2018. The report prepared by the contractor provides more details about the methods applied and experiences made during data collection. The report can be found in Attachment 2.

The statistical analysis of the data was done intermittently in January and February 2018.

1.5 About this report

This report refers to the statistical analysis of 602 SAT questionnaires. The statistical analyses of the individual questions are listed in Attachment 1. If the text refers to individual percentages, then the corresponding number of the question has been added in brackets.

The data collection team provided a picture documentation of each MHP showing the condition of the civil works, the powerhouse, the electromechanical equipment and the mini grid organized in 600 file folders. The author screened most of these folders in a lengthy process. Based on that screening a selection of typical pictures was made and included in this report to underline findings and conclusions.

After describing the general situation found at the MHP locations visited (Chapter 2) each sustainability criteria has been discussed in a separate Chapter (Chapter 3 to 7). In Chapter 8, the results of the scoring system are presented and Chapter **Fehler! Verweisquelle konnte nicht gefunden werden.** provides an outlook about the further use of the survey results.

2 GENERAL SITUATION AT MHP LOCATIONS SURVEYED

2.1 MHP Locations and Population

A total of 602 MHPs were surveyed across Badakshan. Figure 1 shows that virtually all districts were visited for data collection. Only Warduj could not have been visited due to security threats (0-6). 96.6% of these MHPs are located more than 20km away from the national grid, thus the encroachment of the national grid is only a minor risk for the sustainability of these plants (1ie).

Figure 1 MHPs surveyed in Badakshan districts

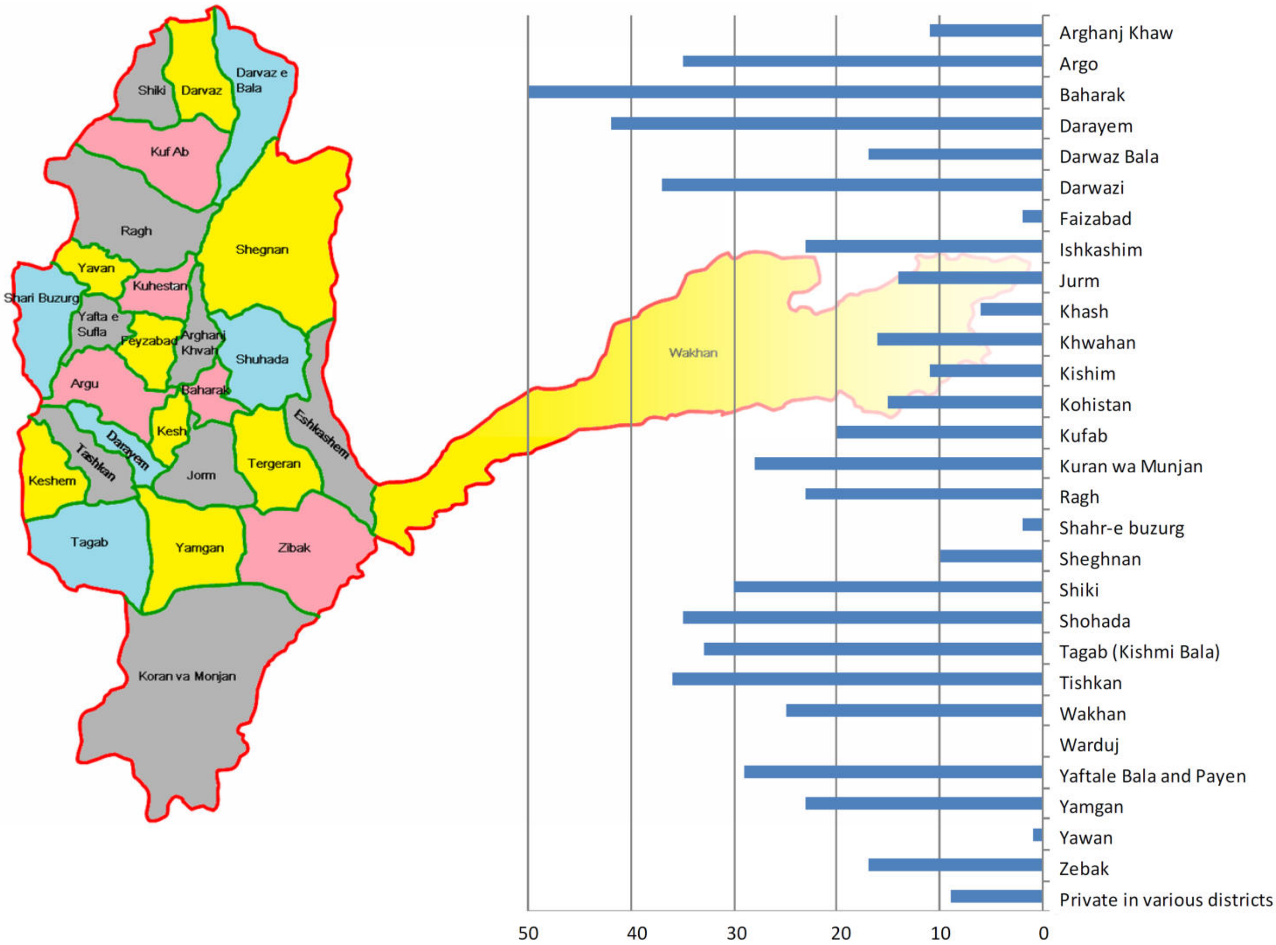


Figure 2 shows the number of households in the villages supplied by electricity from the MHPs surveyed. The average number of households per village was 174. The total number of households at all villages was 104,000. Taking into account the average household size of 8 people per household (CSO, 2017), the average population in a village is 1392. Thus the population living at all 600 MHP locations totals 835,000. The survey showed that 90% of the households in these villages have an electricity connection (average 157.67 households) which corresponds to 750,000 people. Taking into account the fact that 17% of power plant are out of operation (see Figure 5), the total number of people with access to electricity at the time of the survey was **624,000 people** (0-15).

Figure 2 Number of households in villages visited

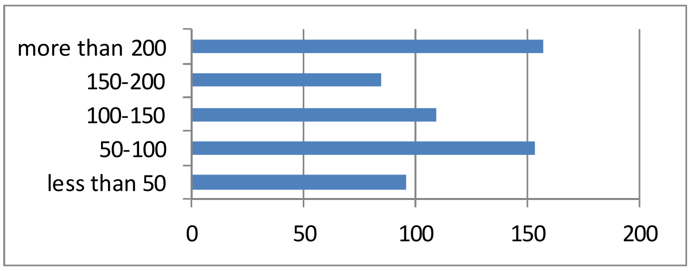
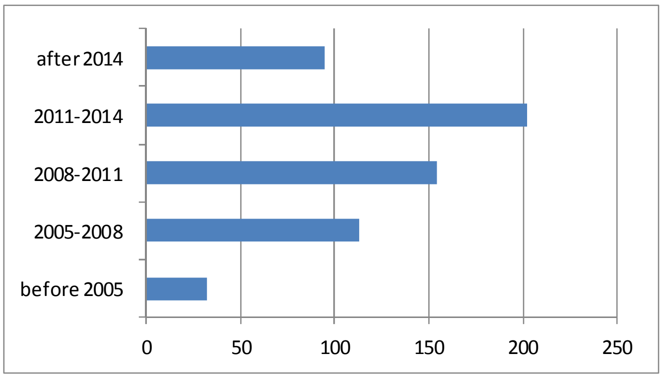


Figure 3 shows that the majority (95%) of MHPs in Badakshan were build after 2005 with a peak activity period from 2011 to 2014 (0-16). Thus, rural electrification is still a relatively new experience for the local population. This fact will have to be taken into account, when interpreting the findings from the survey.

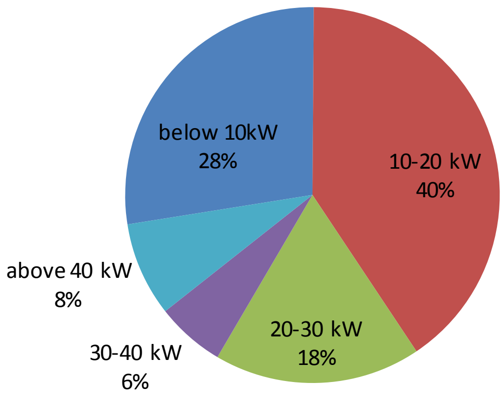
Figure 3 Year of construction of MHPs



0-16

Figure 4 shows that the installed capacity of the MHPs is quite small. 68% have an installed capacity of less than 20kW. The average capacity was 22.08kW per MHP. The total installed capacity of all MHPs surveyed was 13MW (0-17). Thus, the theoretical power available for each household in the sample is 125W, if equally distributed.

Figure 4 Installed capacity of MHPs

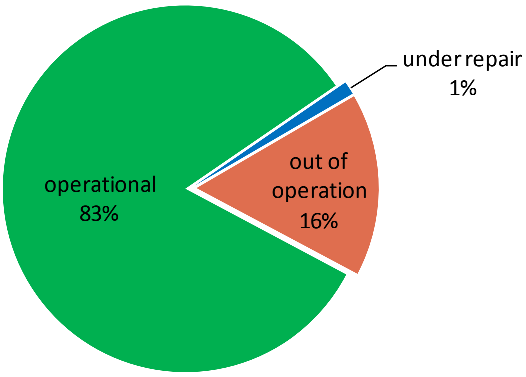


0-17

The reason for the small average capacity is not the hydrologic potential but is more related to the available funds under the NSP program (see below). It was reported that the funds for each MHP were limited, allowing the construction of plants with a capacity range between 10 to 20kW.

Figure 5 show a very pleasant result – **83% of all MHPs were operational** at the time of the field visit (0-22). Compared to international experience, this is a good ratio. The situation would even be better since many of the MHPs were not out of operation due to human neglect but to natural disasters (see chapter 4). The high operational ratio indicates that the population appreciates having access to electric energy and that they are highly motivated to keep these MHPs running. This is a good basis to further develop the sector in the future.

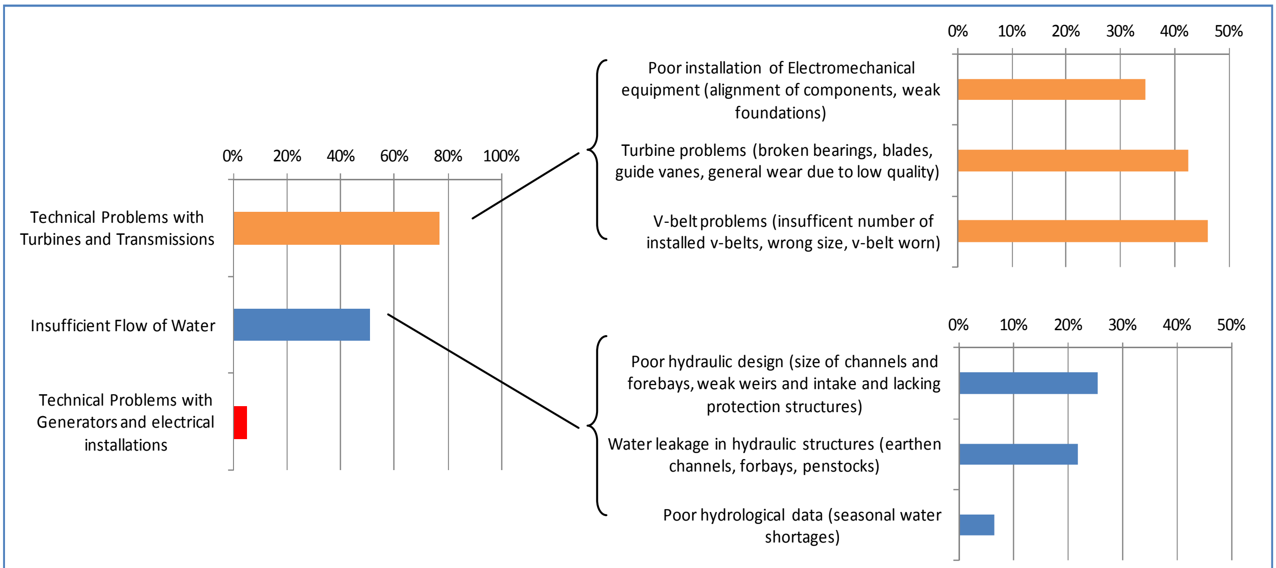
Figure 5 Operational Status



0-22

However, the high operational ratio should not obscure the fact that **most of these MHPs are facing operational problems.** Figure 6 shows that almost 80% of MHP have reported technical problems with turbines and transmissions and 50% reported a lack of water flow mainly due to weak civil works. These problems will be discussed in Chapter 4 to 6.

Figure 6 Fields of operational problems mentioned

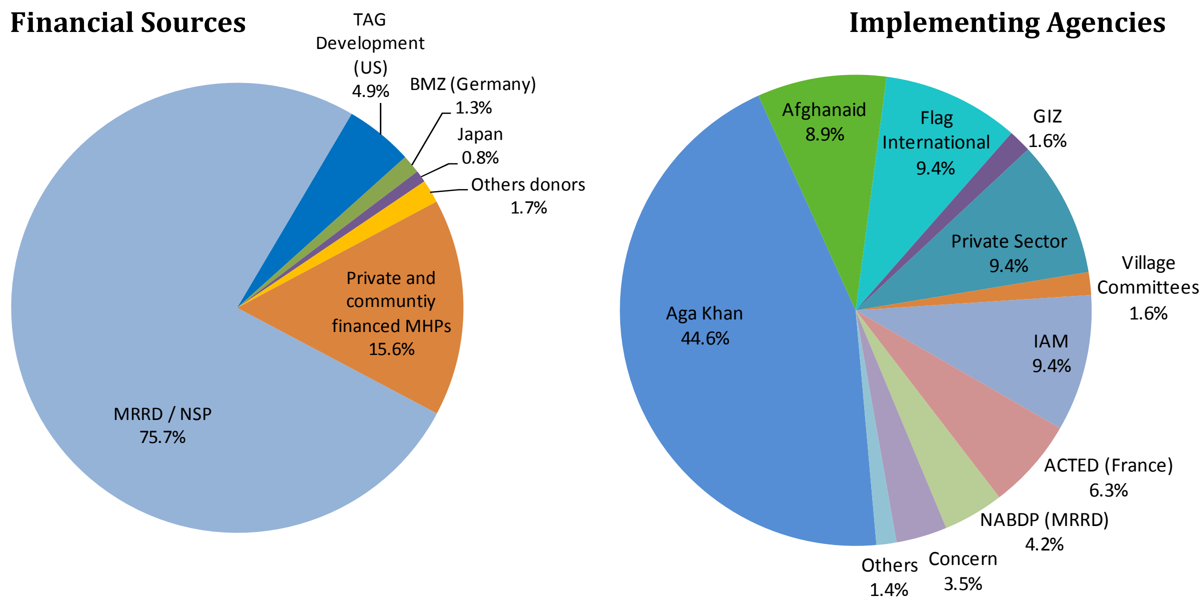


(457 respondents explained their operational problems, multiple problems could be mentioned)

2.2 Financial sources and implementing agencies

Figure 7 shows the sources used to finance the construction of the MHPs and which implementing agencies were coordinating the construction. 75% of all MHPs were funded through Afghan governmental development programs which were mainly coordinated by the Ministry of Rural Rehabilitation and Development (MRRD). Most MHPs were funded through The National Solidarity Program (NSP). NSP was one of the largest, priority programs of the Government of Afghanistan, funded by multiple donors, primarily the World Bank. Around 9% of all MHPs were funded in bilateral programs of international agencies and development organizations. Very interesting is the fact that 15.6% of the MHPs were either built entirely by the private sector or with significant contributions from the communities. The latter was particularly the case for MNP projects of the International Assistance Mission (IAM), where the communities contributed 50% to the costs (0-9).

Figure 7 Financing and Implementing Agencies of MHP programs



The NSP-funded MHPs have been implemented by numerous support agencies. Most MHPs were implemented by the Aga Kahn Foundation, followed by Afghanaid, Flag International, ACTED-France and other organizations. About 20% of all MHP projects were independent of NSP, i.e. the projects by GIZ, the private sector, the self-initiatives of villages, as well as most of IAM's projects (0-8). Interesting is the fact that MHPs funded by the private sector and village communities were also implemented without technical assistance from a MHP program. This shows that a considerable degree of self-help capacity and willingness to invest in basic infrastructure exists within the society in Badakhshan. This is also reflected in the fact, that 96% of respondents said that the MHP projects were initiated by village organizations or village government (0-7).

3 PLANNING AND DESIGN OF MHPs – SUSTAINABLITY FACTOR 1

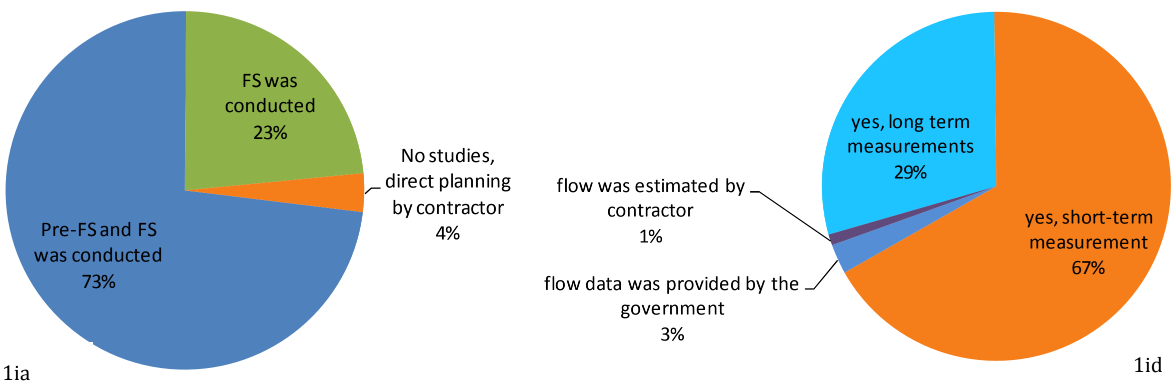
3.1 Feasibility studies and flow measurements

The survey showed that the actual capacity of the MHP is more than 30 percent lower than the installed capacity (0-18). This indicates some significant weaknesses in the planning and design stages of these MHPs. However, Figure 8 contradicts this indication. In 96% of all answers the respondents said that feasibility studies (FS) have been conducted. In 73% cases it was even said that a two step process was made consisting of pre-feasibility study and feasibility study (1ia). In 77% of the cases it was said that the FS also included an electricity demand assessment. 81.57% of these assessment were said to have been also used as a basis for the technical design. Another positive aspect was that 40% of respondents said that the designers of their MHPs took into consideration the possibility of future capacity upgrades (1id). It needs to be noted that respondents were not involved in planning the MHPs, thus their answers need to be interpreted with caution.

While the fact that feasibility studies were made is generally positive, a weakness has been identified in the field flow measurement which is part of these studies.

Figure 8 Feasibility studies and flow measurements

Were feasibility studies conducted? *Were flow measurements conducted?*



A flow duration curve is the most important parameter for the design of hydropower plants. The more accurate the flow duration curve the more economic the design can be made. As shown in Figure 8, long term flow measurements were only used in 29% of all cases. In 67% of the cases, only short-term measurements were made. Short term measurements are not sufficient. The flow regimes of rivers have large variations from one year to another. Ideally, measurements made over ten years or more will be used to develop a flow duration curve. If such long-term measurements do not exist at least a one year hydrologic cycle should be measured and the data be calibrated with the data from a nearby river for which long term data are available. If not long term measurements are available there exists modern remote sensing and GIS technologies to develop models based on digital elevation models and long term rainfall data from weather satellites. Using these technologies can be used to develop flow duration curves for almost any location at low costs.

Using short-term data bears in particular the risk that MHPs will be over-designed for too large water flows which means a waste of valuable funds. Operating such turbines at lower flows also means operating them with lower efficiency reducing electricity production even further.

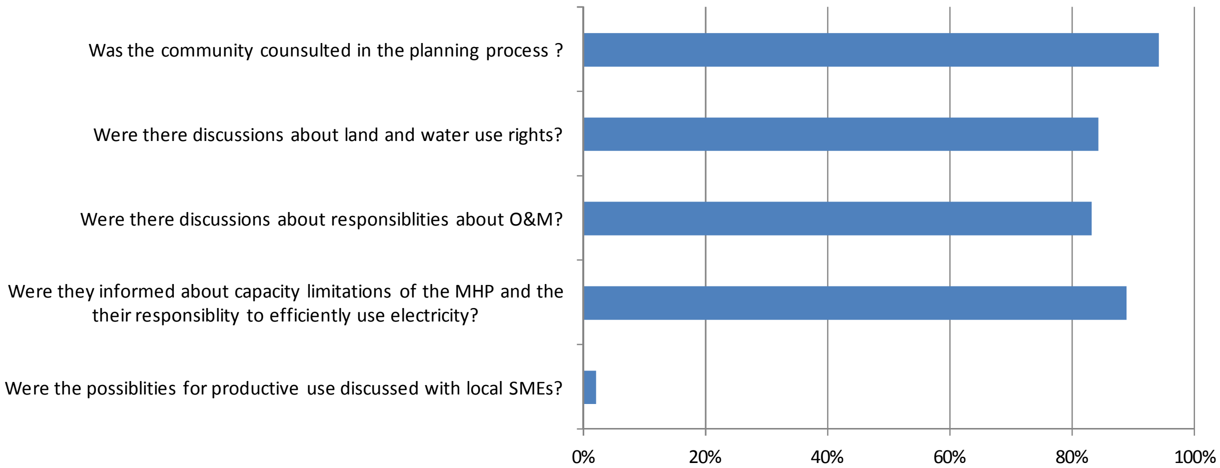
Respondents often mentioned that their turbines suffered from a lack of water or that there are even long periods without water especially in winter time. This may be one of the main reasons why the actual capacity of so many is much lower than the design capacity.

3.2 Community involvement in planning

Figure 9 shows to what extent the communities and local enterprises were involved in the planning process. The people who conducted the feasibility studies indeed consulted the communities in almost all villages (94%). In this consultation process they discussed about land and water use rights, responsibilities about O&M. They also informed the communities about issues around the available power of MHPs and the need to save electricity. Based on the figures it can be said that the MHPs were well socialized with the communities.

However, it is strikingly obvious that the aspects around productive use of electricity and the needs assessment of entrepreneurs were absolutely neglected. This neglect in planning will be reflected in low load factors to be discussed under Sustainablity factor 5 'Electricity use and Profitability' (Chapter 7).

Figure 9 Involvement of community in planning



1if to 1il

4 QUALITY OF CONSTRUCTION AND COMPONENTS – SUSTAINABILITY FACTOR 2

4.1 Contractors

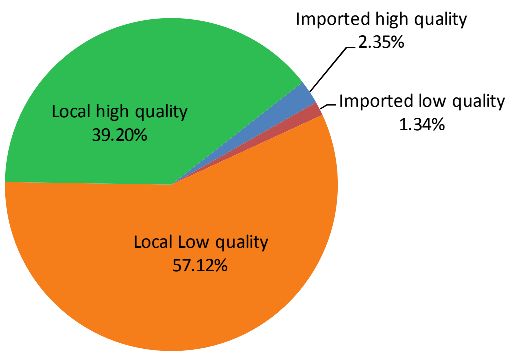
The respondents were asked about who had built their MHP schemes and if and how the construction works were tendered. However, they usually had no detailed knowledge of these processes. Accordingly, the results must be interpreted with care.

In 14% of cases it was said that the facilities were built by specialized MHP developers and in 86% of cases by general contractors without MHP specialization (2ia). It can be assumed that these statements refer to the contractors who were responsible for the construction of the civil works. Interestingly, in 37% of cases it was said that the contractors have a financial share at the MHP (out of 340 replies, 2ic). But there are no further details about the background of these investments. However, these financial shares did not have an influence on the operational status of the MHPs. The contractors were similarly involved with 37% of 'operational' and 37% of 'non-operational' schemes.

4.2 Turbines

No information was provided about the turbine manufacturers or suppliers of the electromechanical equipment and their involvement in the construction and commissioning of the MHP schemes. What is certain is that 96.37% of the turbines were manufactured by local companies and that 97.14% of all turbines are cross-flow turbines (2il). In total, there were only 22 turbines (3.69%) imported (2im). The local turbine manufacturers were certainly also involved in the installation and commissioning of the equipment, only it was not explicitly reported.

Figure 10 Origin and quality of Turbines



2im

Figure 10 shows that the interviewer categorized 57.12% of all turbines as 'local low quality und 39.30% as 'local high quality'. But this needs to be put into perspective. The author's screening of the pictures from the field suggests that most locally manufactured turbines are more appropriately referred to as local medium quality. Many of the turbines have been in use for several years and still serve their purpose. But it is clear that these are not highly efficient turbines.

There are number of smaller turbines that do not offer the possibility to control the flow. These are the turbines to be categorized 'local low quality' (see middle row in Figure 11).

Figure 11 shows several typical turbine-generator assemblies as they can be found at the majority of MHP locations. Turbines and generators are on adjustable baseframes fixed to the foundation. This is a proper setup and allows aligning the shafts of all components. However, the baseframes used are often not stable enough and the fixations of the frames to the foundation are often not sufficient. This is shown in the two pictures at the bottom where heavy rocks are used to stabilize the weak installations.

Figure 11 Typical turbine installations

MHP 4104, locally manufactured turbine

MHP 4118, do

MHP 3044 Low quality turbine without control mechanism

MHP 3106 Often found: mechanically proper turbine-generator assembly but with unprotected generator connections

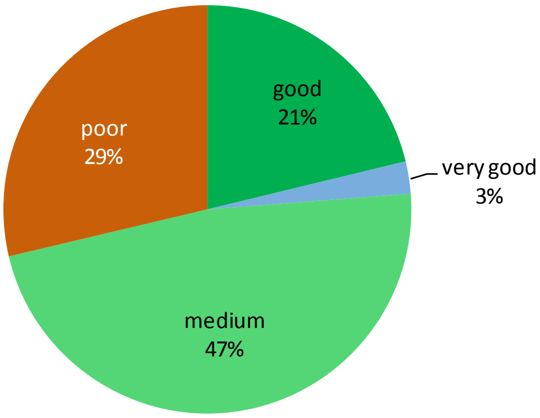
MHP 4124, rocks help improve weak turbine fixation

MHP 3085, do

The pictures confirm that the local manufacturers have the required technical skills to produce cross-flow turbines. This would be a good basis to upgrade their know-how and bring them on the next level of turbine manufacturing in a higher capacity range and improved designs with higher efficiency.

However, the pictures also show considerable weaknesses in terms in installation of the electro-mechanical installations. Figure 12 shows that almost one third of the installations were considered to be poor (2ip).

Figure 12 Quality of electro-mechanical installations



2ip

4.3 Penstock-Powerhouse section

Another frequent design issue identified is related to the joint section between the power house and the penstock. The picture documentation about penstocks is very limited; however, it shows that penstocks may not always be well protected against movement (Figure 13). The penstock supports should be solid enough to fix the penstock with steel straps to the support to restrict movement. Importantly, before entering the powerhouse there should be a thrust block as shown in

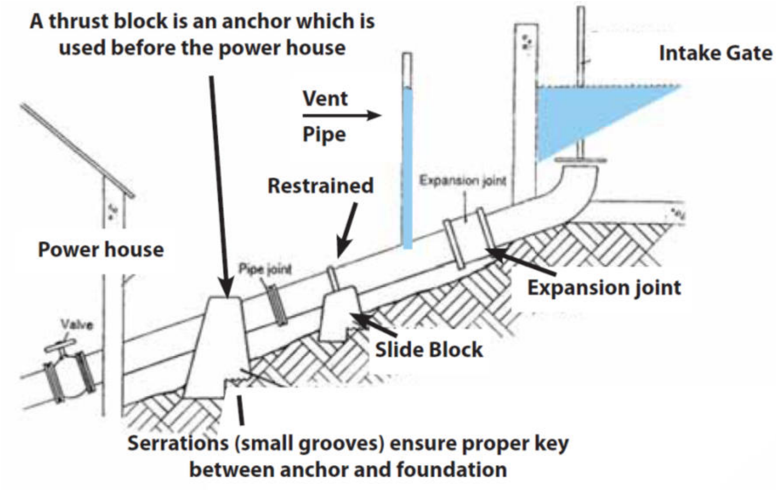
Figure 14.

Figure 13 Penstock examples

MHP 1031, penstock with supports but without thrust block

MHP 1030, penstock without supports and thrust block

Figure 14 Penstock and Supports (Theory)



(source: ACE/GIZ, 2009:85)

When trust blocks are missing there will always be small movements in the joint section between penstock and turbine assembly which can weaken the flange connections of valves and turbines. Figure 15 shows examples of leaking connections which are unprofessionally responded by covering them with cloth.

Figure 15 Leaking joints between Penstock, Valves, and Turbines

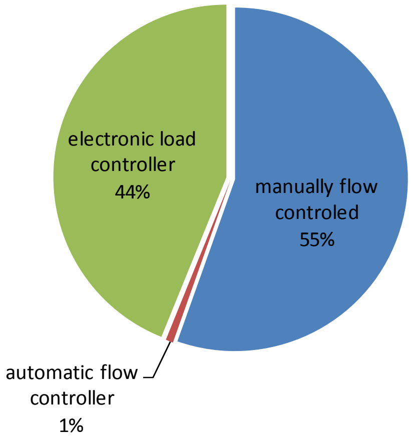
MHP 4157, leaking flange connections

MHP 4129, leaking turbine-penstock connection

4.4 Turbine Control and Electrical Installations

The majority of the turbines (55%) are manually controlled. In 44% of the cases electronic load controllers have been installed.

Figure 16 Turbine control



0-21

The wiring of the control panels is often performed in an orderly way as shown at the example in Figure 17 . The turbine installers have also their own method to properly connect the ballast load tanks as shown in the bottom row. This shows that the technical skills to install control equipment and perform proper wiring are available among technical workshops in Afghanistan.

Figure 17 Quality of Electrical Installations after commissioning

MHP 4104, typical control panel with clearly arranged wiring

MHP 4111, do

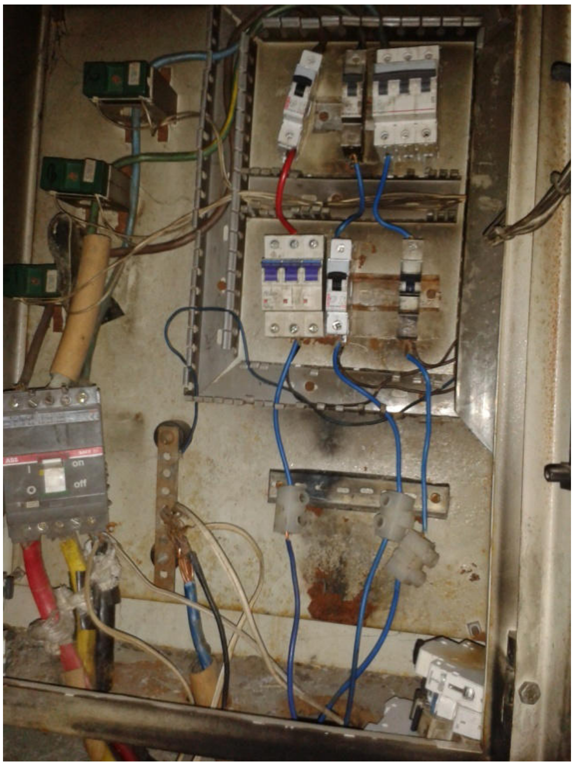
MHP 4135 proper electrical installations but leaking turbine

MHP 4126, propper wiring to the balast tank

However, the picture immediately changes, after local operators or other non-trained villagers try to repair faulty electrical parts. Figure 18 shows some typical example found in the field. These unprofessional installations cannot only cause further technical problems, but are also a danger to life and limb. It is therefore necessary that these MHP operators will no longer be left alone with their problems in the future, but that they have a way to access professional support.

Figure 18 Quality of Electrical Installations after repairs

MHP 3007 Non-professionally repaired control panel



MHP 3007, inside the repaired control panel

MHP 4034, sub-standard generator wiring

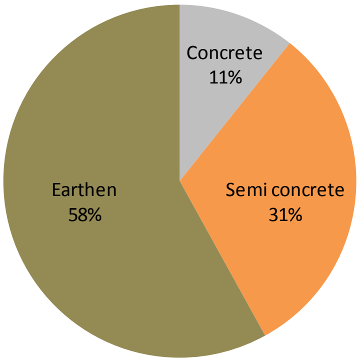
MHP 4039, sub-standard and unsafe electrical wiring

4.5 Civil Works

The intake structures are in 87% of all cases temporary structures (2ig). Such structures are manually built and will be destroyed by default during periods of high run off. Thus, these are very low cost structures but they need to be rebuilt regularly (Figure 20).

As shown in Figure 19, 58% of Channels are also low cost earthen structures. In 31% of the cases channels were categorized semi-concrete. These are mostly masonry structures containing concrete sections. 11% of channels are made in concrete. In fact, the pictures show that in reality at most locations, there is a combination of different channel sections. Since earthen channels are particularly prone to damages by natural events, they often contain masonry sections where they had to be repaired.

Figure 19 Nature of Channels constructed



2ih

Figure 20 Temporary Weirs and Types of Channels

MHP 4122, temporary weir at intake

MHP 2103, temporary weir

MHP 1085, earthen channel

MHP 2100, earthen channel

MHP 4120, earthen channel

MHP 4122, do

MHP 1139, semi-concrete channel

MHP 2017, concrete channel section

Figure 21 shows a number of forebay structures and a channel section built in rather difficult terrain. When looking at the pictures, it is obvious that the civil works are often well executed in terms of pure bricklaying or concreting. However, in many cases, simple hydraulic structures such as spillways and flush gates etc. are lacking or insufficient. Such structures are needed to facilitate controlled overflow of the channels, to maintain the water level in the Forebay, or to removing sediment accumulations. It is therefore not primarily a lack of craftsmanship, but rather a lack of expertise related to designing the different components of a hydropower plant.

Figure 21 Forebays and special structures

MHP 4079, properly built civil works

MHP 4111, harsh winter conditions in Darym distrct

MHP 4048, difficult terrain for MHP construction

MHP 4043

4.6 Poles and Distribution lines

At 97% of all MHP locations visited, electricity was distributed using low voltage (0.4kV) distribution networks only. Medium voltage transmission networks can be found only very rarely.

Figure 1 shows several examples of poles and gridlines found at MHP locations. The quality of poles shows remarkable differences. The initial construction of the mini-grids was often made appropriately. The older the grids are the more it becomes visible that maintenance is also lacking. Tree are not cut back to keep grid lines clear and leaning poles are not straightened again. In some cases there are unsafe installations which are not sufficiently protected from human contact. Regular inspection by a professional maintenance service provider would be required to inform communities about improvements to be made.

Figure 22 Impressions of local distribution grids and poles used

MHP 3022

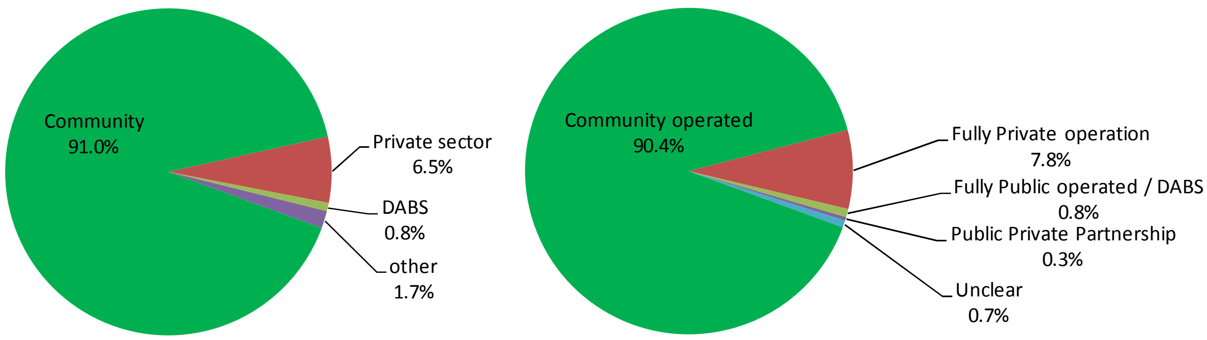
MHP 3028

MHP 3110

5 MANAGEMENT, MAINTENANCE, AND REPAIRS - SUSTAINABILITY FACTOR 3

Figure 23 shows that 91% of all MHPs surveyed were said to be community-owned. 6.5% were owned by the private sector and 0.8% (5 MHPs) were said to be owned by DABS. The latter five MHPs were developed by GIZ under the ESRA program. The diagram on the left shows that the owners are usually also operating the MHPs. The concept of outsourcing O&M to a specialized organization is not applied.

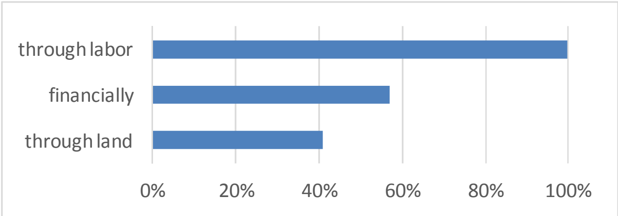
Figure 23 MHP ownership and management models applied



3ia+d

In many countries, community ownership and operation is often a key factor for non-sustainable operation of MHPs. As it was shown in Figure 5, the situation is less severe in Badakhshan with more than 80% of operational MHPs. Possible reasons could be that the majority (72.17%) of MHP management committees were embedded in existing village organizations (3ie). Another reason could be the level of contribution to the MHP construction by the village community. Figure 24 shows that in virtually all community owned MHPs the villagers contributed in kind though labor. In 57% of all cases, villager also contributed financially, and in 41% through land contributions (multiple answers were possible). Such contributions certainly increase the feeling of ownership by the communities which can be the reason that they struggle more to keep MHPs running as compared to other countries where plant were provided on a full grant basis. This is also expressed in a high readiness by the communities to contribute financially, if the MHP need to be repaired. In almost 90% of all cases, respondents said that money for repairs was collected from the community as needed (3ix).

Figure 24 Contribution of the community to the MHPs

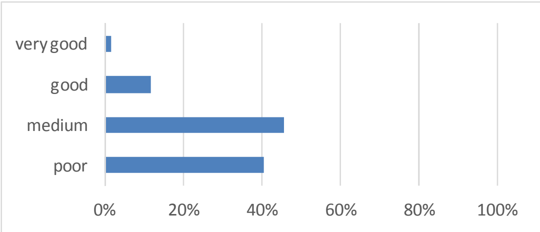


3ic

5.1 Training of operators and management

Most management committees consist of 4 to 5 members, including 1 to2 operators (3if+h). Only 16% of management committees received training in MHP management and administration and only 26% of operators received O&M training (3ij). Considering these figures, the good operational ratio of more that 80% presented above is even more surprising. The self-assessment of the operators regarding their capabilities to operate and maintain the MHPs (3ik) reflects the lack of training (Figure 25).

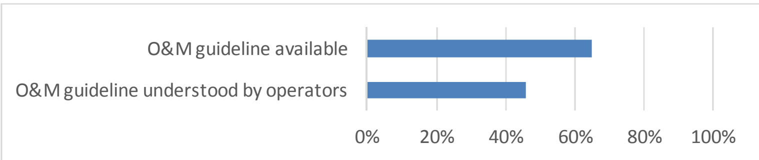
Figure 25 Self-assessment of operators O&M capabilities



3ik

The introduction of regular operators training would certainly be an important step forward. One-off training shortly before the commissioning of MPs is not a solution considering the fact that 57% of MHPs reported fluctuations of operators in the past (3il). Only 8.3% of replacement operator reported to have received training for their new function (3im). The lack of training may be eased to some extent by the availability of O&M guidelines. Figure 26 shows that in 65% of MHPs such guidelines were reported to be available and 46% of operators were said to understand the contents of these guidelines (3io+q).

Figure 26 Availability of O&M guidelines for MHPs

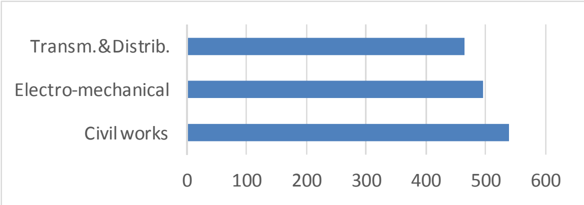


3io+q

5.2 Dealing with technical issues

The surveyed MHPs are often facing technical issues. 31% of all MHPs faced at least one major technical problem and 47% several minor issues over the past two years. Only 2.7% reported no issue at all (3ir). Figure 27 that there is no particular field where most technical problems occur (3is). Virtually all operational power plants faced problems with civil works. These problems are mostly due to temporary weirs and earthen channels. Everyone knows that these are weak structures. Consequently, certain technical problems are already provided in the technical design of weirs and supply channels. However, these can often be remedied relatively cheaply through manual work by the communities without the need for outside support.

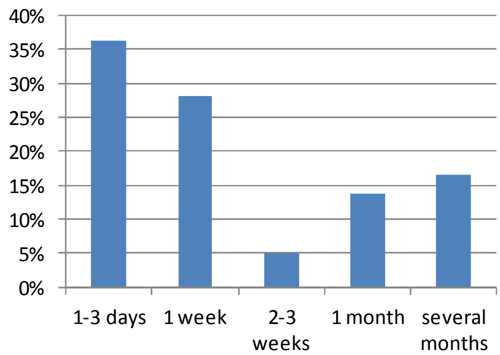
Figure 27 Fields of technical problems faced



3is

The situation is more problematic in case of electro-mechanical and transmission and distribution lines which require support from trained technicians to make sure that repairs are performed in a professional manner. The fact that only in 3.26% of cases the problems were solved by technicians reflects that such technicians are not readily available. Donor organizations helped in 3.61% and governments in 0.5% of all cases (3iv). All other cases were resolved by the communities and operators alone. This lack of professionalism in the execution of repair works is also reflected in the often disastrous appearance of turbine-generator assemblies as well as control panels and electrical installations as it was shown in the previous chapter. Furthermore it is reflected in long down times because villagers need to travel long distances to find spare parts. Figure 28 shows that in 30% of MHPs the downtimes average between one and several months (3iaa). Long down times jeopardize the clients confidence in electricity supply which can prevent entrepreneurs from buying electrical machines and thus leads to low load factors during the daytime.

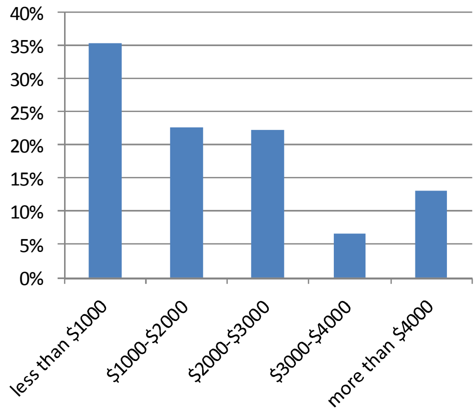
Figure 28 Down times during repairs



3iaa

As mentioned above, in 90% of all cases the money required to pay the repair costs were raised from the community. The average cost mentioned was $2,900 for a single repair (3iw). The average cost per household having an electricity connection is therefore $18.40 which is obviously affordable. In 21% of all community MHPs, there were maintenance and repair funds available. The average saldo was $472 which means that in case of bigger problems it is still required to collect money from the community (3iab+ac).

Figure 29 Costs of most recent repair case



3iw

Similar to the comment made earlier regarding the financial contributions to the investment costs, the way communities handle and finance repairs reflects a high willingness to have electrical energy and a considerable degree of self-help capacity. This is an encouraging potential for future rural electrification projects.

6 NATURAL DISASTER RISKS - SUSTAINABLITY FACTOR 4

As the spider diagrams showed, the MHPs received the lowest score in the sustainability factor 'risk resiliency'. From 595 MHPs, not fewer than 94.12%, it was reported that their MHP had ever suffered damage from natural disasters (4ig). Thus, natural disasters are the most important factors that impair the sustainable operation of MHPs in Badakhshan.

The reason is that most MHPs are located in remote valleys of Badakhshan where rarely any measures are in place to reduce the disaster risk. In case of heavy rainfall the MHPs can be affected by flash floods and mudslides. In winter time, the MHP infrastructure can be affected by snow avalanches and snow storms. In addition to that the whole Hindukush is prone to earthquakes. Figure 30 shows four examples of MHPs that were completely destructed by nature's forces. The totally battered steel tubes of the penstocks clearly show the huge destructive forces that were at work. When choosing the locations of these power plants, natural hazard risks were obviously not considered sufficiently.

Figure 30 Entirely destroyed MHPs by natural disasters

MHP 2010, total flood destruction

MHP 2013, total flood destruction

MHP 2014, total flood destrucion

MHP 2011, total flood destruction

Figure 31 shows the self-assessment of respondents regarding the natural risk level at the location of the power plants. Two thirds said that their MHP is located in an area with very high or high risk of natural hazards (4ib). This high risk exposure was not reflected in MHP planning, design, and training: only 38.38% mentioned that risks were taken into account during in the planning stage (4ic). After commissioning of the MHPs, at only 14.55% locations were measures put in place to reduce disaster risks (4id). Only 21.42% of operators said that emergency planning was part of the operators training and only 28.43% said that they have emergency plans for the most common disasters (4ie+f).

Figure 31 Natural risks level

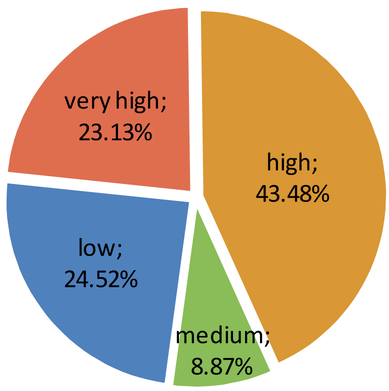


Figure 32 shows that flooding (516 answers, or 92.14%) was by far the most frequent natural disaster that affected the MHPs which ever suffered damages (4ih).

Figure 32 Kind of natural events causing damage to MHPs

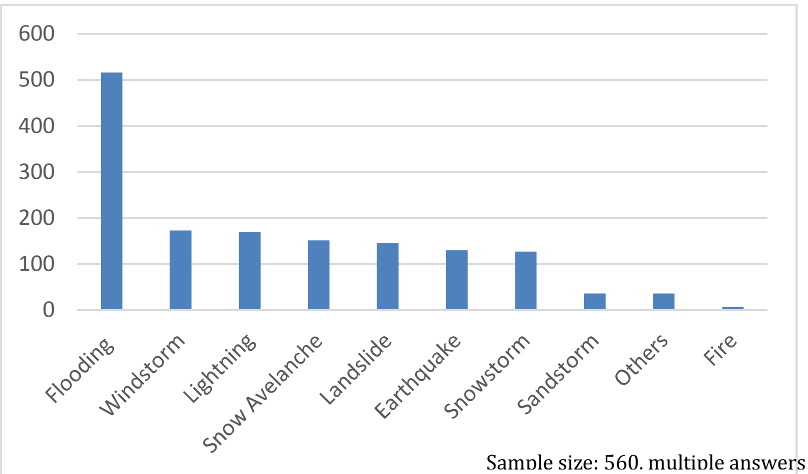
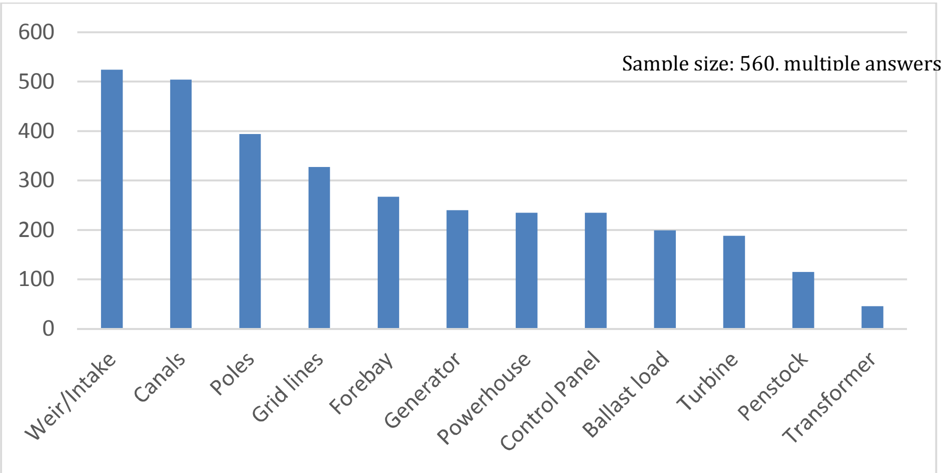


Figure 33 illustrates that the flooding has particularly affected the intake and channels structures. The vast majority of these MHPs (87%; 2ig) do not have concrete permanent weirs but were built by piling up boulders and debris (see Figure 20). Such temporary weirs are cheap and simple structures that can be constructed with local labor, skills and materials. Temporary weirs are expected to be damaged annually, for example after snow melting and rebuilding can be planned in advance. This also means that the damages of weirs are not heavily jeopardizing the sustainability of MHPs since temporary weirs can be rebuilt in a short period.

Headreace channels suffered damages from flooding as frequently as weirs. Headrace channels are often several hundred meters or even more than a kilometer long. Near the intake structures they are also exposed to flooding, but further downstream they are more often affected by landslides or rockfall. 58% of MHPs surveyed had earthen headrace channels which are the weakest structures. 31.27% of MHPs had semi-concrete (masoned) channels, which are considerably stronger. Only 10.7% of MHPs had fully concrete channels (2ih).

Figure 33 MHP parts most affected by natural events



6.1 Recommendations to improve risk resiliency of MHPs

The pictures in this chapter have made it clear that it is not possible to eliminate the risks of natural events merely by constructional protective measures. The forces of nature are simply too powerful. That is why a combination of measures needs to address these risks. The most important measure is a more careful choice of locations for the MHPs so that they are built outside the danger zones, if possible. In addition, structural measures must be provided to protect important plant components.

To improve the identification of safer locations for the MHPs, it would be necessary to carefully study the region and prepare disaster risk maps that take into consideration different flooding and landslides scenarios. Areas prone to landslides and frequent flooding should be excluded from the construction of MHPs.

For each MHP a disaster risk assessment should be compulsory for feasibility studies. If it cannot be avoided that channels lead through risky areas, the sections prone to landslides and rockfall should be made in concrete and specific structures need to be put in place for protection (tunnels, channel covers, walls). Figure 34 shows as an example wire cages filled with stones to protect the downstream structures of Yameet MHP Wakhan District (MHP 1071).

Figure 34 Stone-filled wire cages for flood protection

MHP 1071

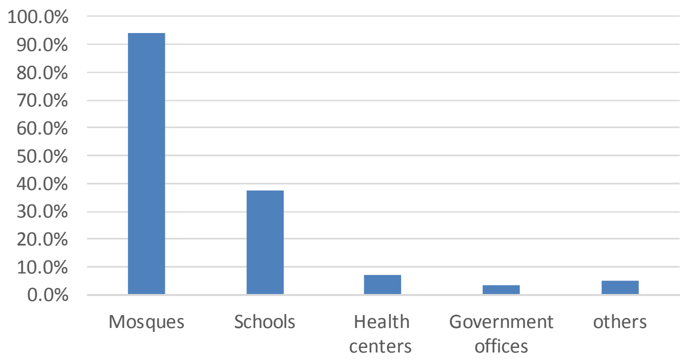
Similar protection structures should be put in place for other civil works such as forebays, penstocks, powerhouses, and grid poles, if needed. Furthermore, there should be emergency plans for the most frequent disasters and operators need to know these plans.

7 ELECTRICITY USE AND PROFITABILITY - SUCCESS FACTOR 5

7.1 Domestic and public use of electricity

As mentioned earlier, the average number of households per village was 174 (0-15) of which 90% had an electricity connection. In addition to that, there were an average of 3 public connections at a MHP locations (5ib). Figure 35 shows that these public users are mainly mosques and schools. In more than 90% of villages, mosques had a connection and in 36% of villages schools were electrified. It needs to be mentioned that not all villages have their own schools, thus the 36% may represent a large proportion of all existing schools at the MHP locations visited. The same may be true for health centers and government offices. In the few villages that have health facilities or separate government buildings, these will very likely also an electricity connection.

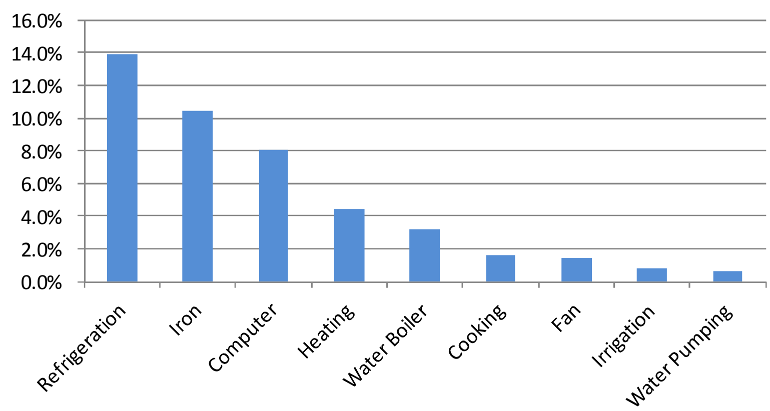
Figure 35 Public electricity use



5ib

The main electricity uses in domestic and public buildings is lighting followed by electronics such as radio and TV as well as phone charging. Figure 36 shows additional used in domestic households besides lighting and electronics. The figures show the percentage of operational MHP locations that reported such uses in at least one household.

Figure 36 Domestic use of electrical appliances besides lighting and electronics



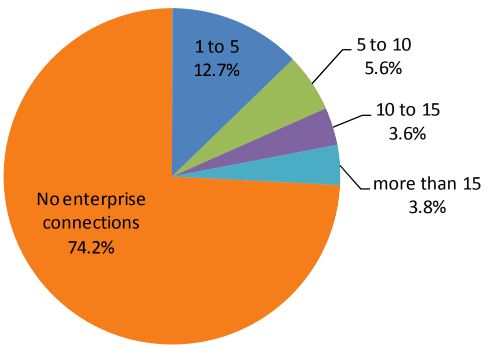
5ia

The figures show that the use of electrical appliances other than lighting and electronics is generally low. The top three are refrigeration, use of irons and computers. Higher power using appliances such as heaters, water boilers and cooking could significantly contribute to increase load factors but are still rarely used. A main reason may be that load limiters prevent the use of such devices with higher power consumption. The use of spare electric energy for heat generation would make particularly sense since it can replace firewood. This aspect will be further discussed in the sustainability plan.

7.2 Productive use of electricity

Figure 37 shows that at almost three quarters of MHP locations there are no enterprises connected to the mini-grid. Compared to other RE technologies, MHP has the advantage that it is suitable to operate power intensive productive processes.

Figure 37 Enterprise Connections in villages



5ic

In one quarter of locations there was at least one enterprise connected to the mini-grid. Figure 38 shows that the majority of these enterprises are retail shops. These shops do normally not have large power requirement as they are mainly use electricity for lighting and refrigeration. The second most frequent type of enterprise connected to the MHP are grinding mills. Figure 39 shows to examples of grinding mills in Badakhshan. These flower mills do not have an engine but are mechanically coupled to the turbine via a V-belt. This means that the mini-grid needs to be shut down while the grinders are being operated. Figure 38 shows a variety of other productive uses at some MHP locations. However, these uses exist at less than 3% of MHP locations.

It can be concluded that productive uses are still very rare. This is a direct consequence from the fact, that possibilities for productive uses were not considered in 98% of all planning processes (see Figure 9). The lack of productive uses means that the electrical power which would be available at 24h per day is largely unused. This restricts the income to be gained from electricity sales, thus limiting the funds available for proper maintenance and repairs. Therefore, productive uses are an important sustainability factor which needs to be paid much more attention in the future.

Figure 38 Type of enterprises connected

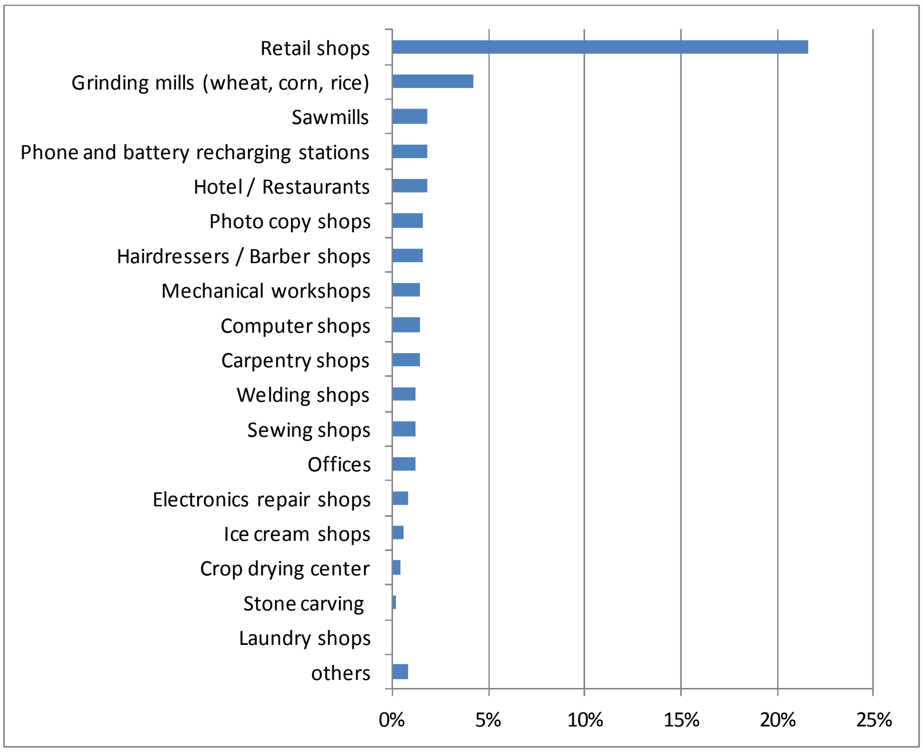


Figure 39 Direct driven flour mills

MHP 4114, productive end-use, possiblity to connect a flour mill via a V-belt to the turbine

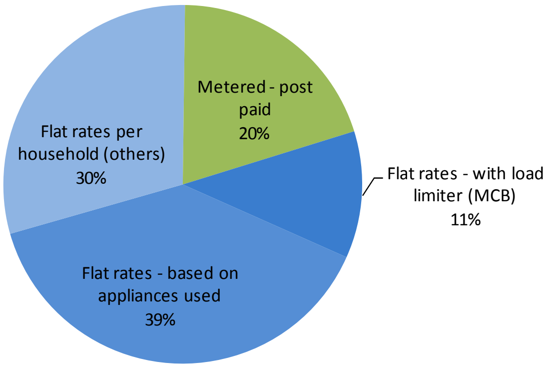
7.3 Tariff systems and tariffs

Figure 40 shows that at 80% of MHP locations flat rate based tariff structures are being applied. In 39% of the cases flat rates are defined in relation to the number of appliances used, such as the number of light bulbs, the number of TVs and refrigerators for example. In average people are charged AFN 15 ($0.21) per light bulb and AFN 30 ($0.43) per TV per month. Most people use 3 to 5 light bulbs.

In 11% of the cases flat rates are used in which the tariff is set according to the maximum possible consumption as limited by an installed MCB. In 30% of the cases tariffs are not based on the load but every household has to pay the same monthly flat rate disregarding the power consumed (5ik). The average flat rate per household was AFN 55 per month ($0.79).

In 20% of all MHPs, kWh meters are installed. Only in 12% of the cases, the national tariff systems was applied where metered systems are in place. In 88% of the cases they developed their own tariff systems. The average tariff charged was **$0.08/kWh** (5io).

Figure 40 Tariff systems applied



5ik

While the metered tariffs are close to the national tariffs (which are low compared to other countries), the flat rates are very low. An average household pays only $0.90 per month which (if multiplied with the 157 average households connected) corresponds to the average monthly revenues from electricity sales revealed by the survey totaling $142 (5ie).

In other words, the monthly fees paid are more symbolic. The revenues generated will never allow an MHP to be operated profitably and it will not allow to pay for proper maintenance of a plant.

As shown earlier in Figure 29, the average funds collected from the community to pay for repaires totaled $2,900 for a single repair (3iw), or $18 per average household. It can be said that the savings the households make with low tariffs later have to be spent for expensive repairs.

The tariff systems were mainly developed by the communities (93% of all cases) (5in). The payment morality was reported to be good (33%) or medium (50%) (5ih).

7.4 Load factors and profitability

Since productive uses are largely absent, the MHPs suffer from low load factors. The average load factor was 35% (5is). This value was calculated with the actual capacity which is lower than the installed capacity. If calculating with the installed capacity the factor would be in the range of 28%. This means that around two thirds of the available power is not used or not sold, respectively.

Considering the low tariffs charged, it is not surprising that most MHPs cannot be run profitably. The international benchmark for O&M cost of small hydropower is estimated with 3% of investment cost. For micro hydro power the percentage can be considerably higher. We estimate in this study that the annual cost for proper maintenance is already 3% of investment cost. Plus there will be the staff cost of the management committees. For the investment cost we are calculating with $3000/kW in this study. Based on this figures and the survey results the following table was prepared:

Table 1 Financial factors for MHP profitability

Item	Value	Source
A. Average capacity	22.08 kW	0-17
B. Average Investment cost	$66,240	IRENA (2012:22)
C. Average monthly maintenance cost	$165	5ir , IRENA (2012:23)
D. Average staff cost	$85	5ir
E. Average monthly revenues	$142	5ie
F. Deficit (E—C—D)	**-$108**	

Table 1 show that the average MHP in Badakhshan is not operating profitably, in fact those MHPs are creating losses. As mentioned earlier, this is also reflected in the fact that significant amount of money have to be collected from the clients to be able to repair the MHPs when needed. Thanks to the high willingness of the people in Badakhshan to keep their MHPs operational this method seems to work. However, in other society these MHPs would most likely cease operation sooner or later.

In any case, it is not satisfactory that MHPs are not able to cover their cost from operational revenues. If load factors would be higher the financial situation of MHPs would be much better. Therefore, these aspects need to be paid more attention in future MHP development.

8 SCORING OF SUSTAINABLITY FACTORS

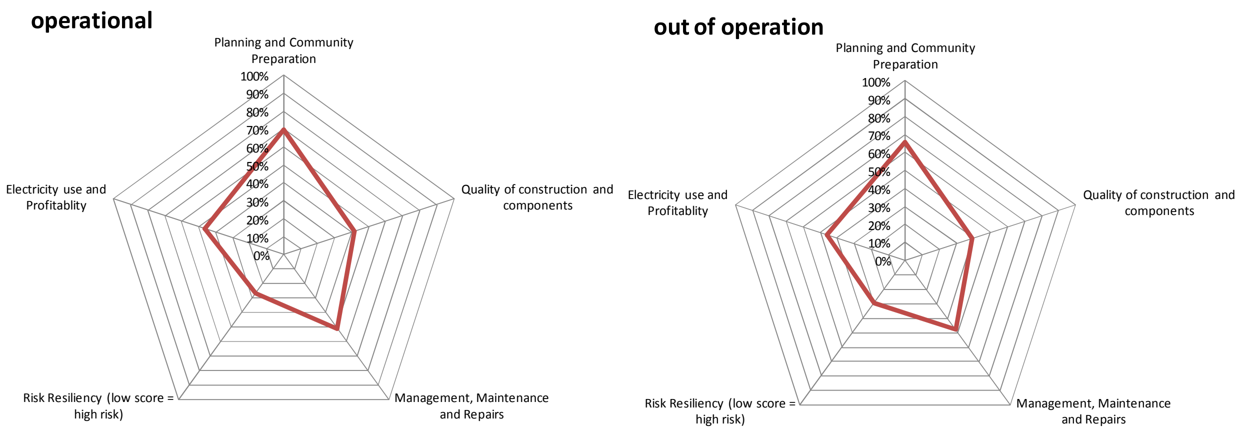
The sustainability assessment tool (SAT) used for data collection contained a scoring system of the five sustainability factors discussed in the previous chapters. The SAT was a standardized questionnaire offering different pre-defined answering possibilities for most questions. These answers were given different weights with regards to their contribution to the sustainable operation of MHPs. The scoring points were given based on the author's international experience with MHP programs. Together with the GIZ team and the survey contractor the SAT tools was discussed several times including the adaptation of the scoring system.

8.1 Comparison regarding operational status of MHPs

Figure 41 shows the comparison of the scoring with regards to operational and non-operational MHPs. The scores of the MHPs which are out of operation show the situation when they were still operational.

The scores in the two diagrams differ only in nuances. Medium scores were achieved in the field of Planning and Community Preparation (70%/66%) and Management, Maintenance and Repairs (51%/48%). Low scores were achieved in the other three sustainability factors. Lowest scores were achieved in the field of Risk Resiliency (27%/29%), indicating the multiple risks encountered in the Hindu Kush valleys.

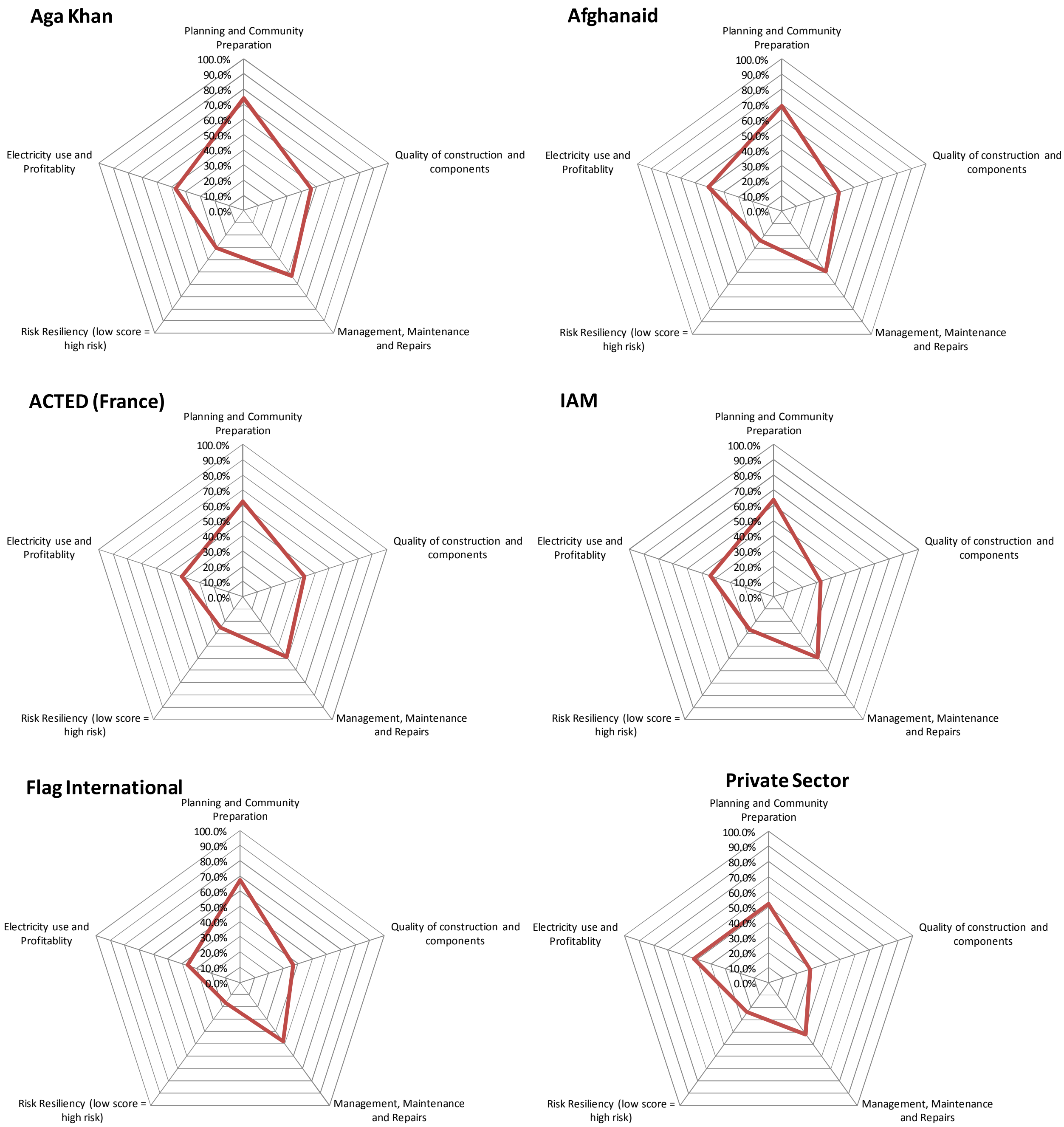
Figure 41 Comparison of MHPs with status 'operational' and 'out of operation'



8.1 Comparison regarding main supporting agencies

Figure 42 shows the clearest difference between MHPs that were built on the initiative of the private sector and those that were mostly built with public funds or donations. The limited financial resources of the private sector are reflected in a significantly lower score in terms of quality of equipment and construction as well as in the field of planning. By contrast, the private sector scores significantly higher in the area of electricity use and profitability. The latter fact reflects that private sector MHPs place much more importance one the productive use of electricity than the other agencies.

Figure 42 Comparison of MHPs supported by different agencies



The organization IAM has also a lower score in the field of equipment quality. This also reflects limited funding due to the fact that IAM requests local communities to contribute significant portions to the construction cost (50%).

Flag International has a particular low score in the field of risk resiliency. This may reflect that the organization is working primarily with very remote communities in disaster prone areas.

In any case, the difference in the above scores is not reflected in significant differences of the operational status. The MHPs that have a lower equipment quality do not stop operating more frequently than the others. A reason may be that these MHPs were built with significant financial contributions from the communities or private owners. If repairs become necessary, then there is also a great willingness to contribute financially.

9 OUTLOOK

As mentioned earlier, the survey results presented in this report were the scientific basis to formulate a **Sustainability Plan for Micro and Mini hydropower (MHP) projects** with a generation capacity of 5 to 500 kW in Badakhshan Province.

For practical reasons, the sustainability plan was compiled as a separate document. Interested parties can obtain the document by contacting GIZ.

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11 ABBREVIATIONS

AFN	Afghanistan Afghani (currency)
AKRSP	Aga Khan Rural Support Program
ANREP	Afghanistan National Renewable Energy Policy
AVR	Automatic Voltage Regulator
BMZ	Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung
CMHPT	Certified Micro Hydro Power Technicians Program
DABS	Da Afghanistan Breshna Sherkat
ELC	Electronic Load Controller
EPC	Engineering, Procurement, and Construction
ESRA	Renewable Energy Supply for Rural Areas
FIDIC	Fédération Internationale des Ingénieurs Conseils
FS	Feasibility Study
GIS	Geographic Information Systems
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
IAM	International Assistance Mission
IDEA	Institutional Development for Energy in Afghanistan
IPP	Independent Power Producer
IVA	Independent Verification Agent
kV	Kilovolt
kW	Kilowatt
kWh	Kilowatt-hour
LED	Light-Emitting Diode
MCB	Micro Circuit Breaker
MEW	Ministry of Energy and Water
MHP	Micro Hydro Power Plant
MRRD	Ministry of Rural Rehabilitation and Development
MW	Megawatt
NABDP	National Area-Based Development Programme
NSP	National Solidarity Program
O&M	Operation and Maintenance
PEC	Provincial Energy Committee
PV	Photovoltaic
RBF	Result Based Financing
RfP	Request for Proposal
RE	Renewable Energy
RED	Renewable Energy Department
SAT	Sustainability Assessment Tool
SMEs	Small and Medium Enterprises
ToR	Terms of Reference
TV	Television

ATTACHMENT 1 – DETAILED STATISTICS OF SAT QUESTIONS

0 General Site Information

0-6	Name of District	# of MHP surveyed
	Private in various districts	9
	Zebak	17
	Yawan	1
	Yamgan	23
	Yaftale Bala and Payen	29
	Warduj	0
	Wakhan	25
	Tishkan	36
	Tagab (Kishmi Bala)	33
	Shohada	35
	Shiki	30
	Sheghnan	10
	Shahr-e buzurg	2
	Ragh	23
	Kuran wa Munjan	28
	Kufab	20
	Kohistan	15
	Kishim	11
	Khwahan	16
	Khash	6
	Jurm	14
	Ishkashim	23
	Faizabad	2
	Darwazi	37
	Darwaz Bala	17
	Darayem	42
	Baharak	50
	Argo	35
	Arghanj Khaw	11
	Total MHP's	600

0-7	Project Initiator		
	Individual villager	0	0.00%
	Group of villagers	0	0.00%
	Villager Organization	415	69.17%
	Entrepreneur	0	0.00%
	School	0	0.00%
	Mosque	0	0.00%
	Health Institution	1	0.17%
	Donor Agency	4	0.67%
	Village Government	156	26.00%
	District/Provincial Government	0	0.00%
	DABS	0	0.00%
	MEW	0	0.00%
	others	24	4.00%
	Total	600	100.00%

0-10	Who is the main Respondent of th	no. of MHPs	% of MHPs
	Group interview with members of management committee	62	10.33%
	Head of management committee	388	64.67%
	Operator	116	19.33%
	Administrator	0	0.00%
	Rate collector	1	0.17%
	Village Head	6	1.00%
	Representative of Donor organizat	0	0.00%
	Others	27	4.50%
	Total	600	100.00%

0-11	**Name and Function of main Respondent 1**
0-12	**Contact Phone Number main Respondent 1**
0-13	**Name and Function of main Respondent 2**
0-14	**Contact Phone Number main Respondent 2**

0-8	Main supporting Agency		
	Aga Khan	257	46.06%
	Afghanaid	51	9.14%
	Flag International	54	9.68%
	GIZ	9	1.61%
	Private Sector	36	6.45%
	Village Committees	9	1.61%
	IAM	54	9.68%
	ACTED (France)	36	6.45%
	NABDP (MRRD)	24	4.30%
	Concern	20	3.58%
	Others	8	1.43%
	Total	558	100.00%

0-9	Project Financier	no. of MHPs	% of MHPs
	MRRD / NSP	451	75.67%
	TAG Development (US)	29	4.87%
	BMZ (Germany)	8	1.34%
	Japan	5	0.84%
	Others donors	10	1.68%
	Private and communtiy financed M	93	15.60%
	-Private financed MHPs	*32*	
	-IAM with community con	*18*	
	-Village financed MHPs	*43*	
	Total	596	100.00%

0-15	Number of Households in th	no of Village	% if villages
	less than 50	96	16.00%
	50-100	153	25.50%
	100-150	109	18.17%
	150-200	85	14.17%
	more than 200	157	26.17%
	Total	600	100.00%
	Average	174.07	
	Median	127	
	Total number of Households	104441	

0-16	Year of completion		
	before 2005	32	5.37%
	2005-2008	113	18.96%
	2008-2011	154	25.84%
	2011-2014	202	33.89%
	after 2014	95	15.94%
	Total	596	100.00%
	Median	2011	

0-17	What is the installed capacity of the power plant?		
	below 10kW	163	
	10-20 kW	239	
	20-30 kW	105	
	30-40 kW	35	
	above 40 kW	48	
	Total	590	
	Average	22.08	
	Total installed caoapcity (kW	13026	

0-18	What is the actual capacity of the power plant?		
	0-10	295	53.06%
	10-20	181	32.55%
	20-30	44	7.91%
	30-40	11	1.98%
	>40	25	4.50%
	Total	556	100.00%
	Average	14.49	
	Median	10	

0-19	Reasons for lower actual capacity?		
	532 qualitative answers	mentions	

0-20	Nameplate Capacity mentioned on Generator?		
	Average	44.26	kW
	Median	37	kW

0-22	Operational status	no of MHPs	% of MHPs
	operational	496	82.39%
	under repair	7	1.16%
	out of operation	97	16.11%
	under construction	2	0.33%
	planning stage	0	0.00%
	Total	602	100.00%

0-21	Type of speed governor used	no of MHPs	% of MHPs
	manually flow controled	312	55.42%
	automatic flow controller	4	0.71%
	electronic load controller	247	43.87%
	Total	563	100.00%

1 i	Planning and Community Preparation		

1ia	Detailed feasibility study conducted?		
	Pre-FS and FS was conducted	420	73.17%
	FS was conducted	134	23.34%
	No studies, direct planning by contracto	20	3.48%
	unknown =27		
	no value = 0		
	Total	574	100.00%

1ib	Did the feasiblity study include an electricity demand assessment ?		
	yes	434	77.09%
	no	129	22.91%
	unknown =5		
	no value = 19		
	Total	563	100.00%

1ic	Was the mini-grid designed in accordance to demand assessement?		
	yes (of total in 1ib)	354	62.88%
	yes (of yes in 1ib)	354	81.57%
	no (probably includes no from 1ib)	203	
	Total	911	

1id	Were water flow measurements undertaken?		
	yes, long term measurements	170	29.26%
	yes, short-term measurement	389	66.95%
	no, flow data was provided by the gov	16	2.75%
	no, flow was estimated by contractor	6	1.03%
	unknown = 21		
	Total	581	100.00%

1id	Modularity (for future upgrade) considered in technical design?		
	yes	225	40.18%
	no	335	59.82%
	unknown =37	0	0.00%
	Total	560	100.00%

1ie	Distance of the National grid		
	<5 km	14	2.37%
	5-10 km	4	0.68%
	10-20 km	2	0.34%
	>20 km	570	96.61%
	Total	590	100.00%

		yes	no	unknown	Total of y/n
1if	are there conflicting water and land uses in the catchment area?	63	534	0	597
		10.55%	89.45%	0.00%	100.00%
1ig	Was the community counsulted in the planning process ?	555	35	10	590
		94.07%	5.93%	1.69%	100.00%
1ih	Were there discussions about land and water use rights?	496	93	9	589
		84.21%	15.79%	1.53%	100.00%
1ij	Were there discussions about responsiblities about O&M?	488	99	13	587
		83.13%	16.87%	2.21%	100.00%
1ik	Were they informed about capacity limitations of the MHP and the their responsiblity to efficiently use electricity?	521	66	12	587
		88.76%	11.24%	2.04%	100.00%
1il	Were the possiblities for productive use discussed with local SMEs?	12	560	9	572
		2.10%	97.90%	1.57%	100.00%
1im	if yes, were productive uses considered in mini-grid design (e.g. separate location or load management)	4	6	0	0

2 i Quality of construction and components

2ia	Kind of company constructing the mini-grid?		
	professional MHP developer	85	14.24%
	several specialized companies	0	0.00%
	non-specialized general contractor	512	85.76%
	Total	597	100.00%

2ic	Does the contractor have a financial share in the mini-grid?		
	yes	127	29.33%
	no	213	49.19%
	unknown	93	21.48%
	Total	433	100.00%

2id	Are contractors selected through competitive bidding?		
	yes	103	22.06%
	no	182	38.97%
	unknown	182	38.97%
	Total	467	100.00%

2ie	If, yes: Are standard bidding documents and contracts used?		
	yes	86	83.50%
	no	8	7.77%
	unknown	9	8.74%
	Total	103	100.00%

2if	Is contractor responsibility and accountability on quality and performance enforced?		
	yes	218	52.28%
	no	77	18.47%
	unknown	122	29.26%
	Total	417	100.00%

2ig	Kind of weir and intake structure		
	permanent concrete	78	13.07%
	temporary (rocks)	519	86.93%
	Total	597	100.00%

2ih	Nature of channels constructed		
	Concrete	64	10.70%
	Semi concrete	187	31.27%
	Earthen	347	58.03%
	no value	0	0.00%
	Total	598	100.00%

2ij	Gross head of the power plant (in meters)		
	<5	120	20.65%
	5-10	229	39.41%
	10-15	96	16.52%
	15-20	47	8.09%
	20-25	28	4.82%
	25-30	21	3.61%
	>30	40	6.88%
	Total	581	100.00%
	Mittelwert	12.6393804	
	Median	9	

2ik	Number of Turbines		
	1	558	94.26%
	2	31	5.24%
	>2	3	0.51%
	Total	592	100.00%

2im	Origin of Turbine		
	Imported high quality	14	2.35%
	Imported low quality	8	1.34%
	Local high quality	234	39.20%
	Local Low quality	341	57.12%
	Total	597	100.00%

2il	Type of Turbine installed		
	Cross Flow	578	97.14%
	Propeller/Kaplan	0	0.00%
	Pelton	4	0.67%
	Other	13	2.18%
	Total	595	100.00%

2io	Type of Generator used		
	Synchronous	598	100.00%
	Asynchronous	0	0.00%
	Total	598	100.00%

2in	Number of Phases of Generator		
	single phase	25	4.17%
	three phase	575	95.83%
	Total	600	100.00%

2iq	Type of Transmission System used		
	Low voltage 0.4 kV only	584	97.33%
	medium voltage 20 kV	7	1.17%
	Other	9	1.50%
	no value	0	0.00%
	Total	600	100.00%

2ip	Good installation of electro-mechanical equipment (visual check)		
	very good	15	2.55%
	good	125	21.22%
	medium	280	47.54%
	poor	169	28.69%
	Total	589	100.00%

2is	What is the estimated length of the distribution system? (in		
	less than 1km	93	15.71%
	1 to 2 km	167	28.21%
	2 to 3 km	132	22.30%
	3 to 4 km	79	13.34%
	4 to 5 km	32	5.41%
	more than 5 km	89	15.03%
	Total	592	100.00%
	Average	3558	
	Median	2500	

2ir	Type of Poles used		
	Wooden	571	95.01%
	Concrete	2	0.33%
	Iron	8	1.33%
	Combination	20	3.33%
	no value	0	0.00%
	Total	601	100.00%

2it	Distribution network and client connections well installed (incl.		
	very good	2	0.34%
	good	97	16.33%
	medium	323	54.38%
	poor	172	28.96%
	no value	0	0.00%
	Total	594	100.00%

2iu	Kind of monitoring and metering equipment installed		
	kWh meters	130	31.78%
	Load limiters	204	49.88%
	Protection MCB only	75	18.34%
	Total	409	100.00%

3i Management, Maintenance and Repairs

3ia	Who is the owner of the power plant?		
	Community	544	90.97%
	Private sector	39	6.52%
	DABS	5	0.84%
	other	10	1.67%
	District government	0	0.00%
	MEW	0	0.00%
	NGO/Donor	0	0.00%
	unclear	0	0.00%
	Total	598	100.00%

3id	What kind of operational models is applied?		
	Community operated	536	90.39%
	Fully Private operation	46	7.76%
	Fully Public operated / DABS	5	0.84%
	Public Private Partnership	2	0.34%
	Unclear	4	0.67%
	NGO operated	0	0.00%
	Total	593	100.00%

3ig	Was the management team trained in mini-grid administration?		
	yes	91	16.08%
	no	467	82.51%
	unknown	8	1.41%
	Total	566	100.00%

3ij	Are the operators trained?		
	yes	156	26.31%
	no	433	73.02%
	unknown	4	0.67%
	Total	593	100.00%

3il	Did you have any staff fluctuations among operators?		
	yes	331	56.97%
	no	241	41.48%
	unknown	9	1.55%
	Total	581	100.00%

3io	Is there an O&M guideline document available for the MHP?		
	yes	266	46.02%
	no	292	50.52%
	unknown	20	3.46%
	Total	578	100.00%

3ic	If community owned, what was their contribution		
	through land	222	40.81%
	financially	311	57.17%
	through labor	542	99.63%

3ie	If community operated, is it embedded in an existing structure?		
	yes	363	72.17%
	no	103	20.48%
	unknown	37	7.36%
	Total	503	100.00%

3if	How many member are in management committee?		
	1-3	227	38.87%
	3-6	257	44.01%
	6-9	60	10.27%
	>9	40	6.85%
	Total	584	100.00%
	Average	4.50	
	Median	4	

3ih	How many operators do you have?		
	1	415	70.34%
	2	161	27.29%
	>2	14	2.37%
	Total	590	100.00%
	Average	1.37	

3ik	What is the capacity of the operators to fix technical problems?		
	poor	239	40.72%
	medium	268	45.66%
	good	70	11.93%
	very good	10	1.70%
	Total	587	100.00%

3im	If yes, did the replacement operators get trained?		
	yes	27	8.26%
	no	298	91.13%
	unknown	2	0.61%
	Total	327	100.00%

3ip	If yes, do the operators have readily access to the guideline?		
	yes	243	93.10%
	no	13	4.98%
	unknown	5	1.92%
	Total	261	100.00%

3iq	If yes, do the operators easy understand the content of the guideline?		
	yes	160	64.78%
	no	57	23.08%
	unknown	30	12.15%
	Total	247	100.00%

3ir	Did the mini-grid face any technical issues in the past two years?		
	No issue at all	16	2.69%
	one minor issue	97	16.33%
	several minor issue	279	46.97%
	one major issue	185	31.14%
	out of operation	17	2.86%
	Total	594	100.00%

3is	If yes, select kind of field of problem:	
	Civil works	539
	Electro-mechanical	495
	Transm.&Distrib.	464

3iv	How was the issue resolved? (most recent problem)		
	resolved by operators	72	12.44%
	resolved by community	439	75.82%
	resolved by local technicians	19	3.28%
	resolved by external provider	0	0.00%
	resolved by donor	21	3.63%
	resolved by Government	3	0.52%
	not resolved	25	4.32%
	Total	579	100.00%

3ix	From what source was the cost covered?		
	Maintenance fund	4	12.90%
	From other community fund	0	0.00%
	Raised form community	0	0.00%
	Donor support	23	74.19%
	from goverment	4	12.90%
	Total	31	100.00%

3iz	How many times over the year has the mini-grid been shut down for repair and maintenance?		
	1 to 2 times	123	21.54%
	3 to 4 times	184	32.22%
	5 to 10 times	144	25.22%
	> 10 times	120	21.02%
	Total	571	100.00%

3iab	If community operated, do you regularly pay money into maintenance fund		
	yes	113	21.32%
	no	407	76.79%
	unknown	10	1.89%
	Total	530	100.00%

3it	Which component caused most problems in the past?		
	Weir/Intake	420	70.95%
	Turbine	123	20.78%
	Canals/Forebay	19	3.21%
	Generator	13	2.20%
	Powerhouse	8	1.35%
	Poles	7	1.18%
	Penstock	1	0.17%
	Grid lines	1	0.17%
	Transformer	0	0.00%
	other	0	0.00%
	Control Panel	0	0.00%
	Ballast load	0	0.00%
	Total	592	100.00%

The answers of this question cannot be used in the an
one answer was possible but several answers were sel
the paper form of the SAT. When transferring it into tl
version only the first one was selected, mostly Weir/Ir

3iw	How much did it cost to resolve the issue?		
	less than $1000	196	35.44%
	$1000-$2000	125	22.60%
	$2000-$3000	123	22.24%
	$3000-$4000	37	6.69%
	more than $4000	72	13.02%
	Total	553	100.00%
	Average	2609.69	
	Median	1544.12	

3iy	Who do you contact if there is a major technical problem?		
	Community	357	64.56%
	Village organization	165	29.84%
	Donor	22	3.98%
	Other	19	3.44%
	Company that constructed th	5	0.90%
	Turbine manufacturer	3	0.54%
	No idea	2	0.36%
	Total	573	103.62%

3iaa	Average duration of shut down for repair?		
	1-3 days	207	36.25%
	1 week	161	28.20%
	2-3 weeks	29	5.08%
	1 month	79	13.84%
	several months	95	16.64%
	Total	571	100.00%

3iac	If yes, what is the current savings amount? (US$)	
	Mittelwert	472
	Median	235

4i	**Risk Resiliency**					
4ia	**Is the mini-grid located in an area with frequent natural disasters?**			4ib	**What is the risk level?**		
	yes	559	93.17%	very high	133	23.13%
	no	40	6.67%	high	250	43.48%
	unknown	1	0.17%	medium	51	8.87%
			99.83%	low	141	24.52%
						100.00%
4ic	**Were the disaster risk systematically address in the planning process?**			4id	**If not, have DRR measures been conducted post commissioning?**		
	yes	215	36.38%	yes	48	14.55%
	no	334	56.51%	no	244	73.94%
	unknown	42	7.11%	unknown	18	5.45%
			100.00%	no value	20	6.06%
						100.00%
4ie	**Was emergency planning taught in operator trainings?**			4if	**Do operators have emergency plans for the most common disasters?**		
	yes	127	21.42%	yes	168	28.43%
	no	453	76.39%	no	411	69.54%
	unknown	13	2.19%	unknown	12	2.03%
			100.00%			100.00%
4ig	**Was the mini-grid affected by any natural disaster?**					
	yes	560	94.12%			
	no	35	5.88%			
	unknown	0	0.00%			
			100.00%			
4ih	**if yes, by which kind of disaster?**			4ij	**If yes, which parts were affected?**		
	Flooding	516	92.14%	Weir/Intake	524	93.57%
	Windstorm	173	30.89%	Canals	504	90.00%
	Lightning	170	30.36%	Poles	394	70.36%
	Snow Avelancl	151	26.96%	Grid lines	327	58.39%
	Landslide	146	26.07%	Forebay	267	47.68%
	Earthquake	130	23.21%	Generator	240	42.86%
	Snowstorm	127	22.68%	Powerhouse	235	41.96%
	Sandstorm	36	6.43%	Control Panel	235	41.96%
	Others	36	6.43%	Ballast load	199	35.54%
	Fire	7	1.25%	Turbine	188	33.57%
				Penstock	115	20.54%
4ik	**Has the mini-grid been insured against the most frequent natural disaster?**			Transformer	46	8.21%
	yes	4	0.68%	Others	0	0.00%
	no	584	99.32%			
	unknown	0	0.00%			
			100.00%			

5i Electricity use and Profitablity

Statistics only include operational MHPs

5ia	How many Households are connected to the mini-grid?		
	0-50	119	19.93%
	50-100	160	26.80%
	100-150	103	17.25%
	150-200	85	14.24%
	>200	130	21.78%
	Total	597	100.00%
	Average	158.407035	
	Median	115	

5ib	Number of Puclic electricity connections		
	0	20	4.0%
	1	127	25.6%
	2	104	21.0%
	3	89	17.9%
	4	63	12.7%
	5	34	6.9%
	6	18	3.6%
	7	13	2.6%
	8 and more	28	5.6%
	Total operational MHPs	496	100.0%
	Average	3.05	
	Median	2	

5ic	Number of enterprises connected to the mini-grid?		
	No enterprise connections	368	74.19%
	1 to 5	63	12.70%
	5 to 10	28	5.65%
	10 to 15	18	3.63%
	more than 15	19	3.83%
	Total operational MHPs	496	100.00%
	Average	2.73	
	Median	0	

5id	For how many hours per day do you operate the power plant?		
	1 to 5 hours	6	1.22%
	5 to 10 hours	43	8.72%
	10 to 15 hours	375	76.06%
	15 to 20 hours	55	11.16%
	24 hours	14	2.84%
	Total	493	100.00%

5ie	What are your average monthly revenues from electricity sales in $		
	less than $50	148	32.60%
	$50 to $100	166	36.56%
	$100 to $150	74	16.30%
	$150 to $200	23	5.07%
	more than $200	43	9.47%
	Total anwers from operational MHPs	454	100.00%
	Average	142.246048	
	Median	73.5294118	

5if	Do you have any records of electricity sales?		
	yes	268	57.39%
	no	199	42.61%
	unknown =12		
	Total anwers from operational MHPs	467	100.00%

5ia	Domestic electricity uses besides lighting and electronics		
	Refrigeration	69	13.9%
	Iron	52	10.5%
	Computer	40	8.1%
	Heating	22	4.4%
	Water Boiler	16	3.2%
	Cooking	8	1.6%
	Fan	7	1.4%
	Irrigation	4	0.8%
	Water Pumping	3	0.6%
	Total operational MHPs	496	100.0%

5ib	Public institutions connected			
		Sum of connections	Occurance in no. of villages	Occurance in % of villages
	Mosques	1184	467	94.2%
	Schools	292	186	37.5%
	Health centers	41	35	7.1%
	Government offices	43	18	3.6%
	others	24	24	4.8%
	Total operational MHPs		496	100.0%

5ic	Type of enterprises connected		
		Occurance in no. of villages	Occurance in % of villages
	others	4	0.81%
	Laundry shops	0	0.00%
	Stone carving	1	0.20%
	Crop drying center	2	0.40%
	Ice cream shops	3	0.60%
	Electronics repair shops	4	0.81%
	Offices	6	1.21%
	Sewing shops	6	1.21%
	Welding shops	6	1.21%
	Carpentry shops	7	1.41%
	Computer shops	7	1.41%
	Mechanical workshops	7	1.41%
	Hairdressers / Barber shops	8	1.61%
	Photo copy shops	8	1.61%
	Hotel / Restaurants	9	1.81%
	Phone and battery recharging stations	9	1.81%
	Sawmills	9	1.81%
	Grinding mills (wheat, corn, rice)	21	4.23%
	Retail shops	107	21.57%
	Total operational MHPs	496	100.0%

5ij	How many kilowatthours do you sell in average per month? (kWh)		
	1-1000	25	29.07%
	1000-2000	18	20.93%
	2000-3000	7	8.14%
	3000-4000	4	4.65%
	>4000	32	37.21%
	Total where using metered systems	86	100.00%
	Average	7068.42	

5ig	if yes, quality of records		
	very good	0	0.00%
	good	70	26.02%
	medium	152	56.51%
	poor	43	15.99%
	not shown	4	1.49%
	Total anwers from operational MHPs	269	100.00%

5ih	**How do you assess the payment morality of electrictiy clients?**		
	very good	30	6.58%
	good	150	32.89%
	medium	228	50.00%
	poor	48	10.53%
	Total anwers from operational MHPs	456	100.00%

5il	**if metered tariffs: are you applying the national tariff structure?**		
	yes	9	11.69%
	no	68	88.31%
	unknown =1		
	no value =4		
	Total anwers from operational MHPs	77	100.00%

5io	**What is the *average* tariff paid per kWh?**	
	Average tariff in metered systems	$0.08

5ip	**How much was the connection fee for a customer?**	
	Average	$75
	Median	$63
	only 191 answers, some of them 0	
	Without free connections:	
	Average	$90
	Median	$74

5ir	**Estimated requirement for monthly maintenance**		
	0-25	59	29.80%
	25-50	104	52.53%
	50-75	23	11.62%
	>100	12	6.06%
	Total	198	100.00%
	Average	163.94	
	Median	120.00	

5it	**Do you still have capacity left to connect more households?**		
	yes	98	22.07%
	no	346	77.93%
	unknown =39		
	Total anwers from operational MHPs	444	100.00%

5iv	**if no, is there a realistic possiblity to upgrade the power plant soon?**		
	yes	227	70.50%
	no	95	29.50%
	unknown = 10		
	Total	322	100.00%

5ik	**What tariff system do you apply?**		
	Flat rates - based on appliances used	173	38.79%
	Flat rates per household (others)	132	29.60%
	Metered - post paid	89	19.96%
	Flat rates - with load limiter (MCB)	51	11.43%
	Metered - pre-paid	1	0.22%
	Total anwers from operational MHPs	446	100.00%

5in	**Who developed the tariffs structure?**		
	Community	410	93.39%
	MHP contractor	5	1.14%
	NGO	0	0.00%
	Management committee/operator	1	0.23%
	Meter reader	0	0.00%
	others	23	5.24%
	Total anwers from operational MHPs	439	100.00%

5iq	**What are the monthly expenses for salaries (management, admin.,**		
	0-25	58	13.00%
	25-50	136	30.49%
	50-75	122	27.35%
	75-100	44	9.87%
	>100	86	19.28%
	Total	446	100.00%
	Average	85.18	
	Median	58.82	

		Averages
5is	**Load factor**	35.20%
5it	**Profitablity**	-111.40%
5iq	**Household connection ratio**	91.66%
5ir	**Productive use ratio (public+commerc**	3.87%
5is	**What is the peak load demand in kW?**	11.99

5iu	**if yes, what is hindering people to get connected?**		
	Connection fee too high	0	0.00%
	Tariffs too high	2	3.92%
	No money to buy appliances	16	31.37%
	Other reasons	33	64.71%
	Total	51	100.00%

ATTACHMENT 2 – DATA COLLECTION REPORT BY SURVEY CONTRACTOR

QADERDAN RURAL TECHNOLOGY DEVELOPMENT WORKSHOP

Final Report

Survey on Assessment of Micro and Mini Hydro Power Plants in Badakhshan, Afghanistan

Contract #: 82356558
GIZ IDEA

Date: December 19, 2017

ARCS Khushal Khan, District 5, Kabul City Afghanistan
Saramiyasht, Khushal Khan, District 5, Kabul Afghanistan
Mobile: +93 (0) 744 12 12 80 - +93 (0) 700 292 363
E-Mail: qaderdan@qrtdw.com - smfazel@qrtdw.com
Website: www.qrtdw.com

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PURPOSE OF THE PROJECT

Appropriate maintenance of hydro and solar power plants is essential to maximize the lifetime and optimize energy yields, serving energy availability and security. Poor maintenance on the other hand, increases project costs due to more frequent operation failure. This concern is especially pressing in rural areas due to limited and costly access to spare parts and repair services. An assessment conducted in recent times by MRRD and USAID shows that multiple solar and hydro projects in Afghanistan are damaged due to improper Operation and Maintenance (O&M) caused by a lack of knowledge and awareness.

Previous assessments have focused on the technical aspects of the operation of power stations. However, numerous other factors (economic, social, environmental and security) contribute to a sustainable operation of a rural power scheme particularly in a destabilized context like Afghanistan. These factors have not yet been systematically assessed.

Assessment Team consisted of National Coordinator, Team Leaders, Enumerators & GIZ Staff in Baharak District

The main objective of this consultancy is to conduct as comprehensive survey of 573 Micro and Mini hydropower (MHP) projects with generation capacity of 5 to 500 kW in Badakhshan

Province. The survey consists of assessing social, environmental, economic and technical factors influencing the sustainable operation of MHPs. The data collected are planned to be used as a basis to formulate a sustainability plan for MHP development and operation. The task is to survey all MHPs in Badakhshan province based on development of specific questionnaires which contains both qualitative and quantitative parts. The project has a duration of estimated 2 months and includes:

1. Preparation and translation of the questionnaires (technical and socio-economic).
2. Hiring and training of Team Leaders and Enumerators/Surveyors.
3. Carrying out the surveys and studies in 573 sites in Badakhshan province.
4. Accumulation of data and Analysis of Data and preparation of the final report.

ASSESSMENT APPROACH

A questionnaire has been prepared by GIZ, which were used to collect the required data. GIZ has developed an Excel-based tool that enables collection and analysis of the data and supports the analyst to draw conclusions and formulate a sustainability plan for MHP development and operations.

The approach taken by QRTDW to carry out the survey are outlined as follows:

1) Four teams of five surveyors were formed.
2) The team leaders work directly under the supervision of the national coordinator.
3) Names and locations of all 573 MHPs were collected from GIZ, MRRD and other sources
4) A detailed schedule and operation plan were prepared to survey the MHPs in all of the 27 districts

INCEPTION REPORT

QRTDW prepared a detailed inception report and submitted it to GIZ/IDEA. The inception report laid down strategy i.e. how to conduct the assessment including the assessment methodology, planned activities, data collection and analysis processes, team composition and resources needed to successfully complete the survey.

PROJECT START UP

Pre-Start Meeting and Team Mobilization:

Several meetings and Skype calls between GIZ and QRTDW management and key staffers were held to develop a good understanding of the following key components of the project:

1) The path taken by GIZ to arrive to this juncture in the project development.

2) The activities undertaken thus far in terms of questionnaire development, staff hiring process and methods, preliminary evaluations of the sites, staff mobilization to the site and other related issues.
3) The technical considerations that build the basis for the start of this project.
4) The expected outcomes of the project as anticipated by GIZ so that the expectations and project activities are carried out in line with realistically achievable and desirable indicators.
5) Regular Skype call with international expert and GIZ to update the progress of the project.

QRTDW formally appointed its team for carrying out all activities associated with phase 1 of the project. The members of the team were qualified engineers and socio-economic experts. The composition of the team was made as per the terms of reference's requirements. All teams (including the team leaders) were assigned to head simultaneously to very remote districts and to survey all sites in those districts based on geographic priorities.

The team leaders were tasked to evaluate all filled out survey forms for completeness and accuracy and send them to Kabul for data entry. The national coordinator was tasked to review the entered data and then forward them to data entry team for compilation, data entry and accuracy and subsequently send them to GIZ consultant for further processing and analysis.

ON SITE DATA COLLECTION

A detailed schedule and operational plan was developed and provided to the team to carry out the study. The plan was shared with GIZ staff and with the assessment team. The plan stipulated timeframe and activities to carry out the assessment. The plan also ensured the following key components:

1. Four teams were established (Group A to D) that each cover around 150 sites. Each team member, including the team leader was tasked to survey about 30 sites.

2. Each team consisted of five surveyors/enumerators. Total of 20 surveyors/enumerators were hired and trained to internalize the questionnaires, understand how to fill the questionnaire, get accurate technical and socio-economic data, etc.

3. All teams started the assessment from remote districts and visit all sites within these districts.

4. Because of the challenging terrains and political conditions as well as the extensive data collection needed, the teams were given sufficient time to ensure that the integrity of collected data is not questionable.

5. A map of all sites were created and a clear sequence of site evaluations were prepared to ensure that at every instance the project leadership is able to assess what site the teams are evaluating and how far they are from completion of the project.

6. The required equipment and logistical support for each team were provided to ensure that each team is able to carry out its work effectively.

7. The teams were given specific instructions to carry out the evaluation.

8. The team leaders were also tasked to actively participate in the survey and remain in the proximity of their other team members. Thus they could visit the team leaders' site to assist.

9. The team leaders were tasked to communicate with the national and/or international team lead in Kabul on a regular basis to ensure that all activities are on track for completion and the integrity of data collected is ensured.

10. At the end of each day, the team leaders were tasked to evaluate the accuracy of the collected data by their respective team members for inaccuracies, inconsistencies, technical deficiencies, missing information or other deficiencies.

11. Each team leader was tasked to send its team's verified reports to Kabul to the national team leader on a daily basis (if internet accesses are available). The administrator and data entry staff in Kabul then ensured that the data are entered and reports are generated.

12. Each site report was being then sent to GIZ consultant or uploaded into the Dropbox or equivalent cloud service.

13. Inputs received from the GIZ consultant were incorporated into the ongoing activities to ensure that mistakes or confusions could be corrected as soon as possible and do not stretch over the whole survey, impacting all data.

Field Test Phase:

The questionnaire was translated into Dari language. The National Coordinator along with team leaders and some surveyors visited one MHP site in Shakardara in order to check the integrity of the assessment, time consumed and problems and deficiencies encountered during the assessment period and identify limitations and challenges faced by assessment team.

At the same time, the visit served as a training session for the assessment team in order to be able to know how to carry out the assessment when they start the actual field survey in Badakhshan.

The team returned to office and analyzed the findings and discussed issues and challenges of the test phase with the GIZ consultant and team via Skype call. Both GIZ and QRTDW team discussed further improvements in the questionnaire and decided to deploy the assessment team to the site to start the survey.

Team Mobilization to Badakhshan:

QRTDW mobilized the assessment team to the site on 24th October 2017. The team arrived in Badakhshan on 25th October 2017. Most of the enumerators including two team leaders were hired from Badakhshan. They were experienced micro hydro experts and worked in similar areas with other international and national NOGs/organizations.

QRTDW arranged an internal meeting for all team leaders and surveyors to explain the assessment plan and their responsibilities. The purpose of the meeting was to ensure all team leaders and surveyors understand the objectives of the assessment and how to carry out the assessment.

Then the National Coordinator met with GIZ's focal point (Mr. Fahim Fazil) to discuss the assessment plan and start of the actual field survey. The following issues were agreed between QRTDW and GIZ team;

1. A one day workshop needs to be held and led by QRTDW team.
2. QRTDW will present its plan for the start of the assessment.
3. QRTDW will need to carry out another field test to ensure the integrity and practicality of the questionnaire and the assessment.

A one day workshop was held in the premise of GIZ on 31st October 2017. The participants of the workshop consisted of GIZ, MRRD, DABS and QRTDW staff. The workshop helped all participants understand the scope of works and the expectation of GIZ out of this assessment. Additionally, the workshop created the platform for cooperation and coordination among its participants.

At the end of the workshop, it was agreed that all surveyors would have to carry out field tests in two MHP sites to enable all surveyors get on the job training to learn the assessment methodology and interviewing processes from each MHP and to be able to understand important components of the assessment.

The test field visits for two sites were conducted on 1st November 2017. The field visit helped all assessment team understand the issues, problems and challenges that they may face during the actual assessment phase. It further helped understand how to conduct the interview to ensure the integrity of the assessment.

QRTDW team spent about eight to nine days in Badakhshan to meet with relevant authorities, receive letters, plan activities, and train all surveyors and team leaders in carrying out the survey.

Actual Assessment Phase

The actual assessment formally started on 4st November 2017. An operational plan was prepared for their field trip and logistic arrangements. Each team leader was assigned to assess certain districts and to maintain regular communications with head of team leaders and national coordinator. The plan was explained to all enumerators. The plan was also shared with GIZ team.

The survey team started the assessment in most remote areas which can be severely affected by weather conditions because they predicted snow and road blockage any time soon in those remote areas. Those districts were Darwaz, Kof AB, Ragh, Shiki, Khahan, Yawan, Shah e Buzorg, Darwaze Bala, Sheghnan and Ishkashem.

The team successfully completed their assessments in those remote sites although phone coverage was very limited and accessibility to communication tools was challenging as well. They conducted the assessment in most of the site (except insecure sites).

Once the teams completed the assessment in the remote areas, they all returned to Faizabad to discuss their findings and to share them with GIZ Badakhshan and with QRTDW main office. Findings and challenges were discussed and analyzed. As a result, the plan was revised for subsequent site visits. The purpose of revising the plan and swapping of some team members to other teams were solely to ensure the accuracy of data collection and the momentum and speed of the assessment process.

After a thorough analysis and revision of the assessment plan, all four teams were deployed to their designated districts. The team visited most of the sites in all districts.

The Surveyors did not face critical challenges in these sites except in Warduj districts. The local authorities informed the surveyor team that they do not recommend them to travel to those MHP sites due to security threats and the fact that most of those villages which have MPH sites are being controlled by the Taliban and it may pose great threat to the surveyors. They also told the surveyors that even the locals have problems transporting fuel and other commodities in those villages. Our team returned and shared the security threat challenges with GIZ Badakhshan office.

The assessment team surveyed the following number of sites in each of the following districts:

List of MHP Surveyed

Survey on Assessment of Micro and Mini Hydro Power Plants in Badakhshan, Afghanistan

No.	Name of District	Total # of MPH	# of MHP surveyed	# of MHP not surveyed	Remarks
1	Darwaz Bala	11	17		
2	Darwazi	28	37	2	
3	Shiki	28	30	1	
4	Kufab	17	20	1	
5	Ragh	30	23	7	
6	Khwahan	17	16	1	
7	Sheghnan	7	10		
8	Ishkashim	5	23		
9	Shahr-e buzurg	2	2		
10	Yawan	1	1		
11	Yaftale Bala and Payen	24	29		
12	Kuran wa Munjan	25	28		
13	Yamgan	25	23		
14	Tagab (Kishmi Bala)	30	33	1	
15	Kishim	11	11	2	
16	Wakhan	15	25		
17	Zebak	13	17		
18	Warduj	26	0	26	
19	Jurm	23	14		
20	Kohistan	21	15	7	
21	Shohada	32	35		
22	Arghanj Khaw	14	11	3	
23	Tishkan	33	36	1	
24	Darayem	37	42		
25	Argo	33	35		
26	Faizabad	11	2		
27	Khash	8	6		
28	Baharak	62	50		
28	Private in various districts	9	9		
Total MHP’s		598	600		

Note: Most of the sites that were not surveyed were mainly due to security threats.

Total numbers of sites surveyed between 4th November to 17th December 2017 were 600 sites in the above 28 districts (except Warduj). Upon their return, they met with head team leader and GIZ's field office and presented their findings in different interval of times. The completed survey questionnaires are being dispatched to Kabul for data entry into the tool provided by the international consultant.

Data Entry

The data entry team have entered all questionnaires/data in the SAT database and updated the GIZ consultant on regular basis. Now all questionnaires are in the database.

Challenges Causing Delays:

The following challenges were faced during this first stage of the project:

1. The contract was finalized and made available to QRTDW to be signed on October 3, 2017 at 2 pm, even though it had been signed by GIZ on September 17, 2017. This put us on a delayed starting schedule.
2. The first draft of the SAT assessment survey tool was provided to QRTDW by GIZ's international consultant on September 29, 2017. However, numerous changes were made to the tool, primarily by GIZ's personnel in Kabul and Badakhshan, so that the final document was made available to QRTDW on October 14, 2017. Only then were we able to start translation of the survey questions. This again caused some delays to the start of our project.
3. A list of MHP sites in Badakhshan was provided to QRTDW on October 13, 2017, the MEW's online resource. However, the list included just under 500 sites, which was short of the 573 sites that were needed for the survey. On October 18, 2017, Eng. Fahim Fazil of GIZ Badakhshan provided a more inclusive list, which was further refined and finalized on October 23, 2017.
4. It was scheduled that the team would start the survey within four days of landing in Badakhshan. In reality they remained in Faizabad for nine days before starting the survey. This was due to the need for additional meetings, training and test site assessments in Faizabad prior to departure.

5. Based on advise and recommendation by GIZ Badakhshan, the team started their site assessments in the most remote areas of northern Badakhshan, which required two days of travel time each way, thus adding 4 days of non-productive time to their schedule.
6. The survey forms could be delivered to Kabul for data entry and submission to GIZ consultant as originally scheduled, because most of the remote areas of Badakhshan lack internet (data) coverage and phone coverage is also fairly sporadic. Thus, the survey forms and photos had to be compiled and sent to Kabul on November 16th for the first batch of 137 sites surveyed and then subsequent batches were sent in different intervals.

The combinations of these factors were the main cause for the delay of the project thus far. The survey teams were on a trajectory to finish the survey work before mid December, which puts us about two weeks post the signing of the contract. However, QRTDW had done what was humanly possible to minimize this delay. A request for time extension was submitted with justification to GIZ on December 7, 2017.

MAIN FINDINGS OF THE ASSESSMENT

QRTDW carried out a detailed assessment of all mini and micro hydro power plants in all districts of Badakhshan province. The survey assessment revealed that even though some of the MHPs are properly functioning and are generating power for the communities' consumption, most of the MPHs are not functioning or are operational below their installed capacities. Even though the local communities were very pleased to have power, they are unhappy to see that most of their sites are not operational. They expected to see those non-operating sites to be rehabilitated so that they again benefit from the blessing of lighting.

The following issues are some of the findings of the assessment:

Power Demand and Productive Use:

1. To access the power demand, the number of beneficiaries' households and their average power demands were not correctly and fully determined in most sites.
2. The possibilities of productive use of the power plants were not often considered during the feasibility studies.
3. Proper socio-economic and technical assessments (feasibility study) were not carried out in most sites. Data collected led to many problems including under-sized plants.

4. The feasibility studies which were carried out in some sites, they have not fully forecasted the load management and power demand.
5. No proper load management was considered during the course of feasibility studies in order to balance the supply of electricity to adjust or control the entire load distribution process.
6. Most of the MHPs have not had uniformed tariff systems. In order to make the MHPs sustainable and operational at all time, it is important to develop systems for tariff payments.

Operations and Maintenance (O&M):

1. The O&M was one key single issue considered as the main cause for poor or non-functioning of the MHPs.
2. Responsibilities of most of the operators were restricted to turning the plants on and off with no O&M obligations, because the operators were involved in other jobs to meet their daily livelihood needs.
3. The local communities are unable to pay for O&M costs. Lack of attention to resolve the small issues, causes to create more complex issues in the long run. There was also no external funding available so that they repair the plants. In some areas, the communities collected wheat from various households who benefited from electricity and sold them and spend the money for the O&M of the plants.
4. The local communities indicated that the problems of some sites were very minor and because they were unable to fix them, more complex technical problem emerged which caused the plant either functioning with problems or not functioning at all.
5. Most of the power plants' operators/electricians had very little (or in some areas completely lacked) knowledge about the proper O&M of the power plants. This issue has caused the power plants not being maintained on regular basis which ultimately caused the turbines' bearings, panel boards, etc. to break down.
6. Some MHPs did not have designated operators. The responsibilities for the daily operations rested with local communities. Daily rotations by unqualified individuals to operate and oversee the power plants left the plant to encounter numerous daily faults.
7. Some/most of the operators who were properly trained by the contractors or other institutions either left the area or are involved in other works and no more oversee the power plants. New operators assigned have very little knowledge or training to properly maintain the operations of the power plants.
8. The capacities or outputs of some MHPs are less than the communities' demand for power. The local communities believe that the design of the system were not done based on the actual demographic of the villages.

Technical and other issues

1. The quality of equipment and materials used in the power plants are fairly low. Both the manufacturing and installation are done poorly and inadequately. The contractors of those sites seemed unprofessional firms.
2. In most sites, the capacities of the plants are determined and reported by their name plates. For example, if the name plate of a particular site stipulates that the capacity of a plant is 30kW, the actual production is probably between 10kW to 15kW.
3. Majority households have accessed to 2 to 4 bulbs (each 24 watts). There is no effort made to replace high consumption bulbs with low wattage LED bulbs with outputs of 7 Watts and lower.
4. Some MHPs are poorly built (including power house, canals, etc.) and/or partially completed due to inadequate budget or budget shortages.
5. Some projects were not properly completed because the contribution promised by local community were not paid (or not paid in time). Some communities confirmed that they paid around 60 to 70% but the contractors reported only 10% community contributions to their clients.
6. Some of the power plants' locations were not selected properly. The reason for this decision was the high costs of building a reticulation system if the power plants had been built on the feasible location.
7. Some of the weirs and intakes were not chosen properly and some were vulnerable to flood, landslides and other natural disasters.
8. Silt basins were not considered in some MHPs. This has caused silt /small stones to enter the canals and ultimately block them.
9. Many forebay were not designed and constructed properly, which caused the water to overflow the forebay.
10. Penstocks' joints were damaged because the flanges were not selected with good standards and/or were not properly manufactured. This issue caused several problems within the power houses.
11. Little preventive measures were considered for some penstocks (and with poor anti rust painting) being exposed to extremely cold conditions. Also, the construction works for some penstocks (with suspended columns) were poorly built and were partially destroyed.
12. Additional power factors due to populations' increase were not considered in most of the MHPs.
13. Most of the power plants lacked lightning arrestor. The contractors had not considered them in the design. The operators said that by the time they were

informed about the problems caused by lack of arrestor, the automatic systems had burned.

14. Most of the power plants did not have suitable and reliable ELC or mechanical governor. As a result, this issue caused to damage the generators due to high speed.
15. Silt issues sometimes caused damage to the turbine runner.
16. The survey team noticed that some MHPs were left uncompleted because the contractor disappeared in the middle of the works and the local communities were unable to finish the remaining works.

Recommendations:

1. Some local conflicts had caused some neighboring communities to be shut out from receiving power. Those communities demanded restoration of power to their local communities so that they also benefit from electricity.
2. Sites, which are damaged due to natural disasters or due to poor quality of construction and the equipment installed, should be repaired and local communities are willing to cooperate.
3. In future, professional companies who have experience and expertise in production, installation and construction of MHPs should be hired to carry out feasibility studies, construct the power plants and install the equipment in a professional manner.
4. A proper management system for O&M for the existing, newly built or future plants should be in place in order to run the plants with none and/or minimum problems.
5. Where there are potentials for bigger power plants e.g. between 500kW to 1MW, efforts are to be made to construct the bigger plants. This will help reduce the O&M costs and continuously sustain the operations with greater employment opportunities for local communities.
6. To make the MHPs sustainable and operational at all time, the power plants must generate adequate incomes to meet its regular O&M costs. It is important to execute and enforce tariff systems which meet the O&M requirements and at the same time, taken into consideration the ability of beneficiaries to pay for this source of energy.
7. The electrification committee and/or governing body are non-existent in almost all MHP sites. It is important to revitalize or re-create these structures in each community in order to oversee the functionality of MHPs and to enforce the payment of electricity bill with applicable policies. The governing body also needs to be linked with local authorities (as a second source of governing mechanism) to ensure they pay their tariffs on regular basis.
8. In order to optimize the use and financial viability of the micro-hydropower plant, the installed capacity should be governed by household demand.

CONCULSION

The survey was successfully completed in all districts of Badakhshan province. The total numbers of sites being surveyed are 600 sites. However, there were some challenges in some districts that our surveyors were not able to conduct the assessment in all sites in a particular district. Most of these challenges were due to security threats, difficult terrain, etc.

APPENDIXES

QADERDAN RURAL TECHNOLOGY DEVELOPMENT WORKSHOP

Inception Report:

Survey on Assessment of Micro and Mini Hydro Power Plants in Badakhshan

October 8, 2017

ARCS Khushal Khan, District 5, Kabul City Afghanistan
Saramiyasht, Khushal Khan, District 5, Kabul Afghanistan
Mobile: +93 (0) 744 12 12 80 - +93 (0) 700 292 363
E-Mail: qaderdan@qrtdw.com - smfazel@qrtdw.com
Website: www.qrtdw.com

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PURPOSE OF SURVEY

Appropriate maintenance of hydro and solar power plants is essential to maximize the lifetime and optimize energy yields, serving energy availability and security. Poor maintenance on the other hand, increases project costs due to more frequent operation failure. This concern is especially pressing in rural areas due to limited and costly access to spare parts and repair services. An assessment conducted in recent times by MRRD and USAID shows that multiple solar and hydro projects in Afghanistan are damaged due to improper Operation and Maintenance (O&M) caused by a lack of knowledge and awareness. Previous assessments have focused on the technical aspects of the operation of power stations. However, numerous other factors (economic, social, environmental and security) contribute to a sustainable operation of a rural power scheme particularly in a destabilized context like Afghanistan. These factors have not yet been systematically assessed.

The main objective of this consultancy is to conduct as comprehensive survey of 573 Micro and Mini hydropower (MHP) projects with generation capacity of 5 to 500 kW in Badakhshan Province. The survey will assess social, environmental, economic and technical factors influencing the sustainable operation of MHPs. The data collected will later be used as a basis to formulate a sustainability plan for MHP development and operation.

Assessment Approach/Strategy

A questionnaire has been prepared by GIZ, which will be used to collect the required data. GIZ has developed an Excel-based tool that enables collection and analysis of the data and supports the analyst to draw conclusions and formulate a sustainability plan for MHP development and operations.

The approach taken by QRTDW to carry out the survey will be as follows:

1) Four teams of five surveyors will be formed
2) The team leaders will work directly under the supervision of the national coordinator.
3) Names and locations of all 573 MHPs will be collected from the following sources:
    i. GIZ
    ii. Agha Khan Foundation
    iii. Afghan Aid
    iv. NSP
    v. USAID
    vi. Any other sources
4) A detailed plan shall be prepared to survey the MHPs in all of the 27 districts including the following:
    i. Wakhan,
    ii. Kishm,
    iii. Baharak,
    iv. Jurm,
    v. Yaftal Pain,
    vi. Yaftal Bala,

vii. Ragh,
viii. Orgu,
ix. Darayem,
x. Arghanchkhah,
xi. Nosi,
xii. Shoki,
xiii. Mahami,
xiv. Ishkashim,
xv. Khash,
xvi. Khahan,
xvii. Kofab,
xviii. Kohistan,
xix. Kiran-o-Manjan,
xx. Shahr-e-Bozorg,
xxi. Shoghnan,
xxii. Shohada,
xxiii. Tabab,
xxiv. Tishkan,
xxv. Worduj,
xxvi. Yamgan, and
xxvii. Yawan-o-Zibak.

It is expected that some districts may not have any or have very few MHPs installed.

Most of the dams are built on one of the most significant rivers in Badakhshan, including Kokcha River, Wakhan, Warduj, Tagab, Tangi Shiwa, Pamir, Jurm, Agherdah, Ghori Sang, Darwaz, Ragh, Zarqul, and Chaqmaqin. SSOme dams may be built on tributaries of any of these rivers.

All teams (including team leaders) will head simultaneously to one district and survey all sites in that district based on geographic priorities. Thereby, the concept of low hanging fruits will be used, so that easier sites will be completed first while most difficult sites will be done at the end.

At the end of the day, the team leaders will evaluate all filled out survey forms for completeness, plausibility and accuracy. Missing information, unclear data or implausible information can be corrected though phone conversation with the contact persons on site as well as the surveyor. The completed survey forms will be scanned and sent to Kabul, where data entry personnel will enter the data in the tool. The national coordinator will review the entered data and then forward them to GIZ consultant for further processing and analysis.

Planned activities

A) Following signing of the contract, a one-day joint meeting of GIZ and QRTDW management and key staffers shall be held to develop a good understanding of the following key components of the project:

a. The path taken by GIZ to arrive to this juncture in the project development.
b. The activities undertaken thus far in terms of surveys, reports, lists, interim evaluations, etc. so that a good understanding of the situation is available with QRTDW team members.
c. The financial and technical considerations that build the basis for the start of this project.
d. The expected outcomes of the project as anticipated by GIZ so that the expectations and better understood and project activities are carried out in line with realistically achievable and desirable indicators.

B) QRTDW will formally appoint its team for carrying out all activities associated with phase 1 of the project. This team includes personnel with a combination of the following capabilities:

a. Community mobilization and engagement skills and experience, including in-depth cultural awareness, language skills, verbal and non-verbal communication skills that are conducive to achieving mutual respect and trust in the relationship.
b. Technical skills to understand relevant issues such as assessment and calculation, water assessment and calculation, equipment assessments, assessment of technical capabilities of Hydro power personnel, power distribution system assessments, etc.

C) The GIZ consultant has prepared a questionnaire and an Excel based tool to enable data collection, data entry and data analysis. Three to four members of QRTDW, including operations and some team leaders will participate in Skype call with the GIZ consultant and review the tool and receive training on its use. Thus any questions or ambiguity regarding the tool and the survey questions will be resolved.

D) A letter of introduction will be prepared by GIZ to all relevant agencies and ministries so that QRTDW can request and receive information about all MHP projects in Badakhshan.

E) QRTDW will also carry out a sample survey at an MHP in the proximity of Kabul in order to test the tool developed by GIZ. The outcome of the sample survey will be shared with the GIZ consultant to ensure that all aspects of the survey are also fully taken into consideration.

F) In the mean time, the complete team will be hired and the survey will be started.

Phase 2 – On-Site Data Collection

A) A detailed schedule and operational plan will be developed and provided to the team to carry out the study. The plan will ensure the following key components:

a. Four teams will be established that will each cover about 130 sites. Each team member, including the team leader will survey about 23 sites.
b. Each team will consist of five surveyor/enumerator. Total of 20 surveyors/enumerators will be hired.
c. All teams will be launched in the same district and will visit all sites within that district.
d. Because of the challenging terrains and political conditions as well as the extensive data collection needed, it is critical that the teams are given sufficient time to ensure that the integrity of collected data is not questionable. Hence, we believe that more than one month will be needed to survey all sites.
e. A map of all sites will be created and a clear sequence of site evaluations will be prepared to ensure that at every instance the project leadership is able to assess what site the teams are evaluating and how far they are from completion of the project.

B) The required equipment and logistical support for each team will be procured or provided to ensure that each team is able to carry out its work effectively. GIZ will provide GPS devices while QRTDW will ensure that they have cameras and other tools on hand.

C) The teams are then sent on the road to carry out their evaluation.

D) The team leaders also actively participate in the survey and remain in the proximity of their other team members. Thus they can visit the team leaders' site to assist, should help be needed.

E) The team leaders will communicate with the national and/or international team lead in Kabul on a regular basis to ensure that all activities are on track for completion and the integrity of data collected is ensured.

F) At the end of each day, the team leaders will evaluate the accuracy of the collected data by their respective team members for inaccuracies, inconsistencies, technical deficiencies, missing information or other deficiencies. The team leader will resolve the issue and where needed will call the MHP operator to get further clarification. Where absolutely necessary, the team leader will also visit the site to ensure the integrity of the survey data.

G) Each team leader will then e-mail its team's verified reports to Kabul to the national team leader on a daily basis. The administrator and data entry staff in Kabul will then ensure that the data are entered and interim reports are generated. Any challenges faced will also be resolved and corrective measures taken to ensure easier work during the coming days.

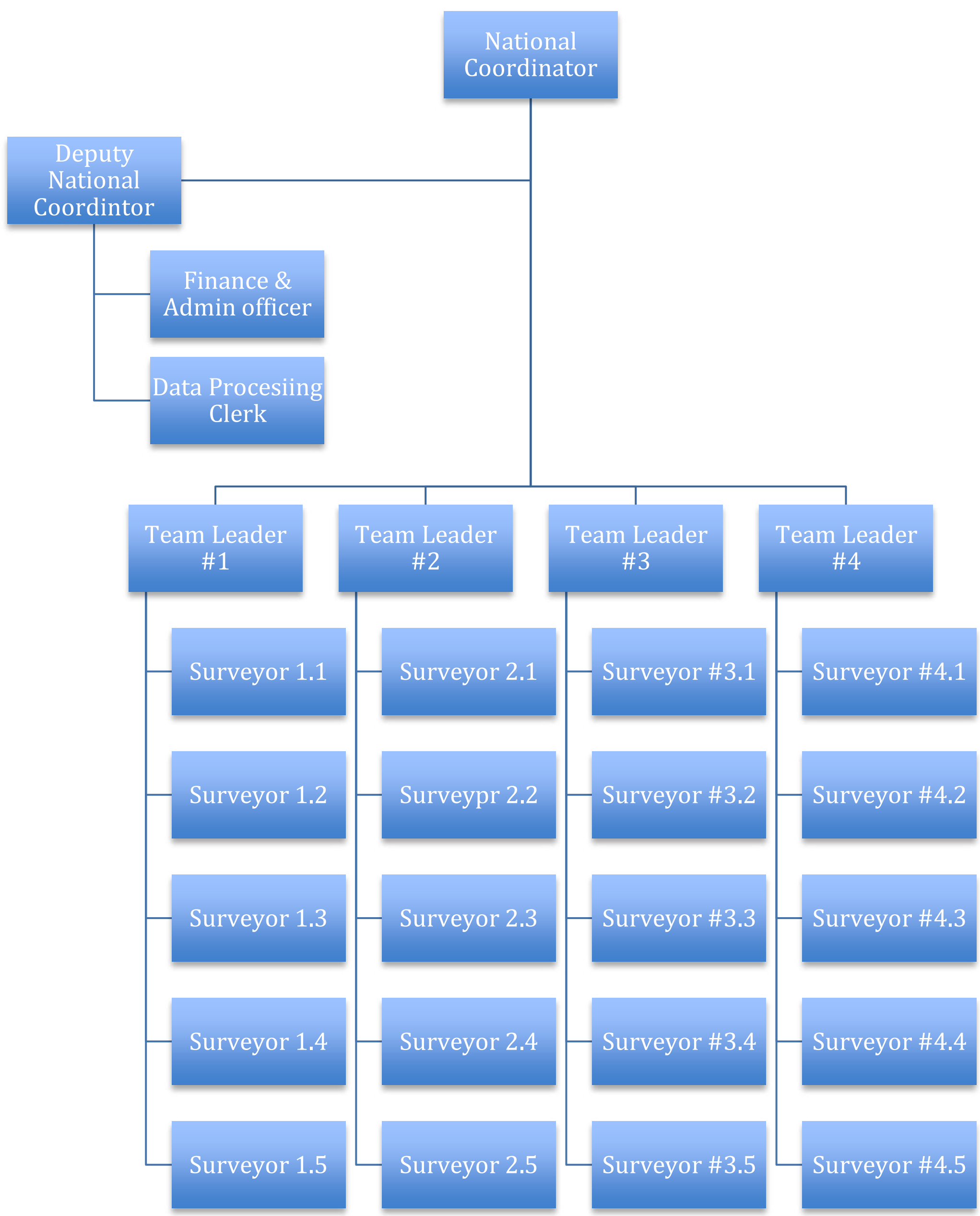
H) Each site report will be e-mailed to the GIZ consultant or uploaded into the Dropbox or equivalent cloud service.

I) Inputs received from the GIZ consultant will be incorporated into the ongoing activities to ensure that mistakes or confusions can be corrected as soon as possible and do not stretch over the whole survey, impacting all data.

Phase 3 – Data Analysis

The GIZ consultant will analyze most of the survey findings. QRTDW will be available for help and clarification, where such help or clarification is needed. Any other assistance needed by the GIZ Consultant will then be assigned to QRTDW and QRTDW will complete such additional tasks.

Team Composition / Structure



Resources/Facilities

We have access to the following resources:

1. The personnel required for the project as listed above.
2. All surveyors and team leaders will be provided with cameras. Team leaders will be given access to laptops, phones, Internet connection and other communication equipment.
3. Team members will be provided housing, transportation and other logistical support
4. Office staff will have access to all office and administrative equipment and tools.
5. GIZ will provide GPS devices (24 pieces) on a loan basis for the duration of the survey.

Security Considerations

QRTDW will carry out all surveys in person and will indicate location of every MHP with a GPS indicator. In locations, where the security situation will endanger the life and property of our team members, QRTDW will try to utilize remote communication to collect the necessary and required information.

Project Schedule: