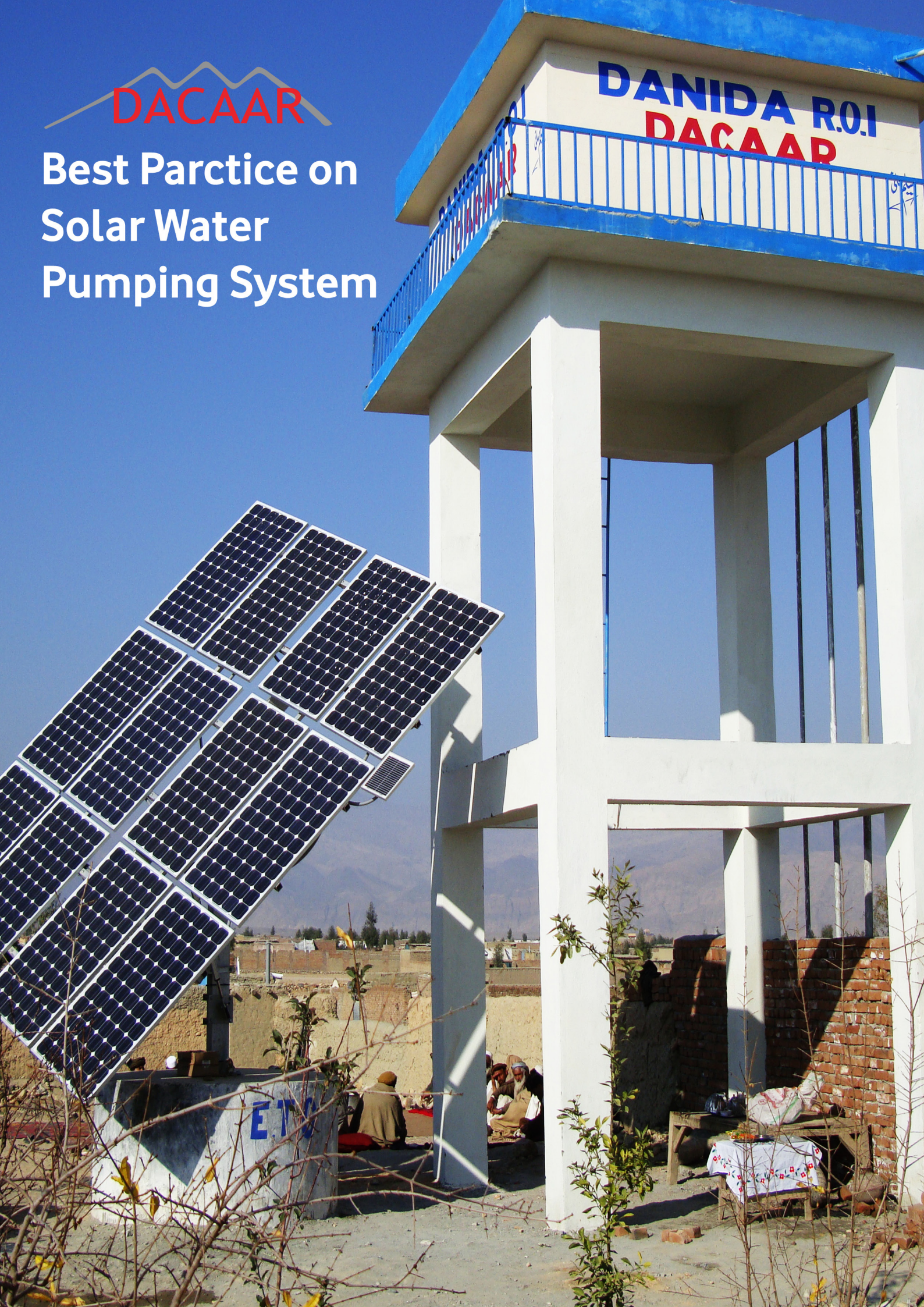
DACAAR

Best Parctice on Solar Water Pumping System



Cover photo:
Solar Water Pumping system in Surkhrood district of Nangarhar province.

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1. Introduction

Normally a solar pumping water supply system is only installed and provides safe water when water table in a borehole is too deep for a hand pump to function (water table is lower than 60 meter), the borehole is well developed and the yield is sufficient (pump test is a must when using electro pumps or any other mechanically driven pump).

Solar water supply systems have proven to be one of the water supply systems that can prove to be cost effective over the long period of time if used to supply up to a maximum of 25 liter water per person per day within a Water User Group (WUG). The WUG should be preferably large enough to have 6-7 tap stands within the same community to reap the benefits and are able to look after the system.

Solar systems are relatively expensive in comparison to other alternatives but give free and relative low levels of running costs and are long lasting when well laid out. There are a few draw backs namely during cloudy weather the delivery of water is lower than on clear days. The system must be carefully designed and the borehole must be tested on potential output and static water level.

The cost of a typical system would cost about $43 per capita against a hand pump of $40 per capita. The solar system will require a paid caretaker and cost for the replacement of taps and other small repairs, while the caretaker in the case of a hand pump will be a member of the WUG of only 20 families, while the solar water system will have between 100 and 150 families in the WUG. A caretaker should be trained in repairing, looking after the system and keeping the panels dust free.

The cost of the systems depend on many factors some that are local specific and some more general like price of imported items. Even the price of the imported items can vary depending on the mark-up from the local providers. So take care by comparing prices with other providers and their technical know-how, if they have spare in stock, provision of guarantee, repair workshop and expertise of their personnel (training cost) and general equipment.

In the case of DACAAR: DACAAR provides an additional pump as spare to be given during hand over as such cannot be afforded if breaking down. Panels are the responsibility of the community as such can be damaged by careless handling, theft or vandalism. A system that is placed at the end of project can be better secured against thieves and other potential disturbances. The community must be informed about costs of all components, how and where providers can be found (up to 2015 mainly in Kabul), replacement costs in case of careless maintenance of the solar water supply system.

The delivery of water is a clean issue with solar and with a well-designed system can last and give a satisfactory output. With most systems there is also the possibility of connecting a generator to solve the problem of cloudy days. Many of the components can last for many years, especially solar panels from reputable firms are guaranteed to work for 25 years and are known to work for fifty years. The electronics used are also more reliable than previously. Pumps are reliable but have to be expected to break

down at some stage. Therefore buying items that are easily available from a local firm is a better option than just importing from abroad with no local backup or spares available.

The technical aspects can be a major problem if the provider has not the technical personnel to install the system. The installation aspect is especially problematic if the system cabling is not done correctly or the pump and panels do not match. Good workmanship is important to ensure lasting quality function of the solar water supply system.

The more solar systems are installed the more likely that there will be more than one reliable provider and the problem of availability of spares in the various parts of the country will be solved while at present all firms appear to be concentrated in Kabul for obvious marketing reasons.

DACAAR did some practical research and has in 2015 already five years of experience and installed more than 40 systems in the field successfully and the majority are functional. DACAAR is still following up the installed systems to learn from installed systems, support the community in settling community problems and give support in solving technical problems and training of technicians. Therefore, DACAAR wants to share the lessons learned and experience as a best practice document with all interested and relevant sector players.

2. Methodology

This Best Practice document is written on the basis of action research on solar water pumping system, desk study on design and costing from procurement and project documentation, follow-up on field experience, previous findings report on short comings' (internal report) and rectification of all problems (except stealing of panels and damage to panels (bullet holes).

3. Objectives

- To provide information for interested parties, organizations that want to start with solar pumping and designers;
- Support those organizations in implementing solar pumping systems;
- To demystify the concept of solar pumping systems;
- List the components needed in the design of solar pumping systems;
- Particular issues to be aware off about the solar pumping systems;
- If the system is cost effective in terms of per capita cost;
- Information for users in case the system gives problems;
- Highlight the issues that are of importance such as costing and caretaker etc.

4. Criteria for installation of Solar Water Pumping System

Solar systems have become reliable and more affordable but require a certain level of technical and design expertise to make the system to function optimally and according to output expectations.

Criteria for using a solar water supply system must be in place.

1. One of the criteria in DACAAR is that the water bearing layer is below the depth what a hand pump can manage.
2. The area to be served is under-served because of the problem of drilling and other technical factors.
3. Community management is possible, this can only be ascertained after dialogue with the community members and the elders.
4. Placement of the system is of particular interest to minimize vandalism and stealing by placing solar

supply systems at the safe location so that the panels cannot be reached.

5. Sun shines at least for a half day, as in some areas sun doesn't shine for 1-3 months in winter.
6. Population should be considered, the number of families serve by system to be more than 100 families.
7. Water quality test to be done for chemical, physical and biological contaminates before implantation of system.

5. Preparations

Solar system needs the same preparations as with all piped systems, but solar pumping might have a restriction on the number of persons to be served by one system. Pump selection and quantity of panels depends on the yield of the borehole and the number of persons to be served. Output of solar pumps can be increased by adding solar panels up to limits as indicated by pump manufacturers. Depth of the borehole might become a limiting factor against cost of panels to lift the water. The greater the depth of the borehole will result in more panels to give sufficient current to get the water from the well. Information on borehole and site specifications and solar power need to be gathered.

In the case of a high yielding borehole more than one pump could be placed below or above depending on the draw down level as found during pump testing.

The quantity of panels will also depend on the placement if they are placed on ground level fixed, can be adjusted manually or a tracking device will be used. The number of panels on a tracking system will be substantially less than with a fixed or semi-fixed system.

6. Technical Survey

The area selected must be surveyed and the hydro-geologist can indicate the better place for drilling, but taking into account the various criteria as mentioned previously. Besides the criteria, input from community members must be collected who will be potentially served by the system. The borehole needs to be well constructed. The well must be pump tested and then the final decision can be made to start the process of procurement. The most important factor to make a decision is the attitude and interest by the community.

A survey of the area is essential as otherwise the design team cannot size the pipes and the tank required properly. The organization need to have in-house capacity to design water supply systems and otherwise rely on consultants. Providers of solar system can only provide technical support after being given the amount of water needed, yield of borehole, depth of well and safe depth for pump, height and or distance from well to tank (height difference) and piping to be used. Area of intervention as they have to estimate the solar intensity of the area to give a reasonable seize of the solar array needed (in quantity and quality of panels).

7. Household Data Collection

Besides the technical data, household data need to be collected from the community namely:

- Number of households and inhabitants to supply water
- Water usage,
- Capability of community to maintain the system,
- Willingness of looking after the system and
- Other community aspects that might be deemed necessary for a good functioning of a solar system.

8. Well Drilling

The construction of the well is best done with a percussion drilling rig as then the hole will be clean and ready to use. The well still need to be drilled straight and lithographic data collected so that the organization knows about water bearing layers encountered to place the gravel pack and the filter parts at the correct places.

In rocky areas or in areas that generally no percussion drilling rig can be used a rotary drilling rig will have to be utilized. The organization will have to budget for such eventuality as rotary drilling is rather expensive ($150-$200 per meter and possibly mobilization fee) in Afghanistan. The drilling need to be well supervised as rotary drilling owners tries to make short cuts. They very often do not bother to take samples of the material coming out of the well. Therefore, knowing the exact depth and type of formation where water can be found is important for placement off well screens and depth of pump placement.

Most of the rigs come with a mud pump but not with a compressor. A compressor is essential to develop the well. Developing a well is cleaning out the mud used during the drilling process (clogging all pores) and essential to open all the places that can contribute to water entering the well. Development of well and placement of the correct gravel pack are essential to ensure that there will be low turbidity.

9. Pumping Test

A compressor is also required to do the test pumping as most of the rigs do not have water pumps. The yield of a well can be established with a compressor that delivers sufficient pressure which will depend on the depth of the well. Water has to be put in a stilling basin before being measured as water pumped with a compressor comes out in gusts and not constant as with a pump. Pump test is essential to establish the safe yield of the well and the cone of depression as well as the recovery rate.

10. Design of System

First step would be to collect information from the areas selected for solar water supply. Under normal circumstances such areas that are selected have a water table that cannot be extracted anymore with a hand pump. The well must have sufficient yield to provide water for the local community and solar might have limitations for quantity delivered (mind you this could be overcome by putting more than one pump in the well provided that the yield and draw down would be in acceptable limits for the system). The better option would be to have one pump for one community and the next well should be sufficiently distant so that the influence on the water table will not affect the nearby well.

11. Cables/Wiring

Cabling for electricity needs to be done according to specifications from the pump manufacturer and depends on depth and length of cabling from source as well on the type of pump used. A 12 or 24 or variable DC voltage system is more difficult to size properly and the cabling will be significantly thicker than an AC based system.

12. Panels

Solar panels do give a DC type of electricity and in most systems is then converted through a converter into AC voltage as the cabling needed is a lot thinner and therefore cheaper than DC voltage. Presently DC pumps are available whereby the electronics create a pulse. The converters have become very reliable. In all cases the conversion is done above ground level. While additional electronics might be placed in the control box or as for the Grundfoss system in the pump body. But the cables from the panels to the converter must be properly sized. The voltage is of importance and the load it will carry as well as the distance between panels and converter.

The amount of panels needed can be best designed by the provider. The panels come in different formats and output is different according to size and quality of materials utilized. The quantity of panels also depend on if the panels are placed in a fixed position (take more panels), semi adjustable according to season (normally angle can be changed) and less panels are needed for a tracking system (cost additional for tracking system). Providers might have different levels of experience in placement; the simple placement is the fixed position while the tracking system needs a good foundation to withstand wind.

13. Starting box/Converter

Every pump has an On/Off switch externally. Within the box the DC voltage from the panels is often converted to AC voltage and therefore thinner electrical cables can be used. Some of manufacturers use DC voltage motors with strong permanent magnets that are robust and do not require oil as a lubricant, the lubrication is by water and as well as the cooling. Every manufacturer indicates the type of cable to be used against the length (or depth setting of the pump). The box has normally also connections for an external generator, two probes for inside a well (sometimes as one probe) and two connections for probes to be placed in the tank for stopping and starting the pump.

14. Batteries

The use of batteries in pumping systems is not recommended. If one wants to make use of batteries, the batteries need to be sized and the allowable discharge to be taken into account. A battery system cannot use car or lorry batteries they must be real solar batteries in which the lead plates are thick and come normally in 2 volt sections for very heavy use or 6 volt for heavy use. There are many commercial batteries for special purposes but are expensive, but come with up to 7 year guarantee.

Thick cables should be used on batteries and the length should be as short as possible. For instance if an AC pump pulls 10 Amp then the requirement from a 12 volt battery would be 100 Amps. In such cases even thick wires will get warm.

15. Pump

Selection of the correct pump that fits the design criteria and meets the needs of the community are very important. The solar water pump provider should advice in the correct pump type and panels required. The provider will require a number of data before such advice can be given (namely depth of well, pump test results, distance from pump to reservoir, height difference and placement (GPS data) and other potential data they may want). Personnel can be trained or informed about the criteria of selection but the provider should propose a pump based on all the details as demanded by them.

16. DC or AC pump

The majority of the pumps available for solar systems are variable AC pumps that work with panels through a converter in the starting box. The pump starts pumping at a specific delivery of current and will stop when the solar electricity will drop beyond a drop in electricity generated.

Most start up boxes have connections for an external power source like generator and connections for the probes to be used in borehole and tank, for stopping and starting the system.

All pump manufacturers have performance curves for the most suitable pump to be used and how many panels (often expressed in watt) against depth. Many manufacturers have specific programs to aid in sizing of a proper system or handed over the calculations to their distributors as the clients might not properly size the cables and other components that might lead to failure of the system and the manufacturer getting a bad reputation (while the fault might be with the client).

Newly designed DC motors are brushless and are cooled and greased by the water being pumped. Such DC motors do have permanent magnets and the electronic box pulses the current that causes the motor to spin. Such motors are from a variable speed type and will not be damaged by changes in current.

17. Type of pump

There are a number of pump types that are suitable for solar pumping.

1. Most likely to encounter is the multistage centrifugal pump with closed coupled electric variable motor (a must as output of panels depend on intensity of the sun on the panels).
2. Helical Water pumps with direct coupled electric motor
3. Centrifugal or helical pump with motor on surface (unlikely to be seen in Afghanistan – needs a shaft to connect to surface motor).

There are in the world a number of organizations that provide pumps for solar pumping like Grundfoss, Lo-

rentz, Mono pump, Shakti Solar pumps and others depending on providers in country that can deliver such systems. Systems are available from India, Italy, Germany, Denmark and China and others but the reason for selecting a certain pump type should depend on the service provider in country and their experience gathered over time.

By far the easiest option is the centrifugal pump but helical pumps are available and can be more compact but the temperature of the water must be known as that is critical for the helical water pumps. The temperature is important not for the rotor but for the rubber in which the rotor rotates.

18. Probes in wells and tank

Probes are often left out but this is not a good practice. Probes in the well will stop the pump before the water level drops in the well below a level that the pump will start sucking air and running dry might ruin many pumps as cooling and running depends on water to be present in the pump. One probe is a cut-off and the one placed above will restart the pump again (or a combination of the two). Probes can be placed in tanks as well so that no water gets lost through pumping excess water into the tank. Properly designing the system and doing a pump test will minimize the problem of pumping below level and over-filling the tank.

19. Piping

Suitable pipe sizes (also how smooth the bore is) must be selected to minimize friction and ensure optimal functioning of the system. Every bend and obstruction in the system will have a negative effect on the output of the system and this will be more felt in a solar system as the system will take longer to start-up, stops earlier and will not deliver to expectations.

20. Community Organization

The community organizational aspect might take more time than all the preparations and other activities together. The discussions and preparations with the community for the acceptance of their participation and running of the solar water supply system must be finished before actual works can start on the ground. If the community is not able or not willing to take care of the system then the implementation should not be done. Therefore discussions with the community and their acceptance of all conditions or preconditions as well as signing the agreement of their involvement in their willingness to look after the system operation and maintenance.

The community must be explained about the approach, their involvement before and after the installation of the system. The organization need to support the community also after the installation as the system is not well understood or not technically supported as yet in the nearby towns.

21. Operation and Maintenance

The solar water pumping system must have a guarantee from the provider of three years to show their confidence in the system and their support to the community, this guarantee might have to go through the organization that paid for the system components.

The community need to be trained in the O&M of the system and every half year needs to be checked through a process whereby the community caretaker and committee members are re-evaluated on their knowledge and their executing the duties they agreed upon on behalf of the community.

When a change of caretaker/mechanic takes place the organization must work with the newly appointed person till the duties are clear and the expertise needed has been transferred.

22. Collecting funds

The solar water supply system has almost no running costs, but the caretaker/mechanic needs to be paid and taps have to be replaced frequently (depending on the quality of the taps) and standpipes might get damaged.

The caretaker should be the mechanic at the same time and should be instructed on how to change taps and repairs of standpipes and other components that might experience problems. The mechanic gets the necessary tools, the contact details of stores where to buy replacement taps, the knowledge of cost and other items required. For more complicated repairs, the providing organization might still give advice and provide support when needed to ensure that the system keeps on being functional.

The caretaker must be instructed how to move the panels if the panels are not fitted with a tracking device.

23. Organizational Issues

Many issues can be mentioned here as the community approach must be managed and all the other components and issues as previously discussed and mentioned. Without support from management and the proper understanding of all issues and bringing together all the expertise, the project cannot become a success.

The below mentioned issues are not the only organizational issues but come under project management and needs to be dealt with

23.1. Procurement

Procurement should not start till the community has signed and agreed with the approach, their involvement and their O&M aspects are secured. Then the next step is collecting all technical information. Some of the information will only be available after drilling the well, but tube well information might be available from nearby constructed tube wells for starters before being able to give the final information of the well about yield and depth setting of the pump. Pump type and quantity of solar panels and cable length will depend on the technical information from the well. Each of the aforementioned components will have a bearing on the total price of the system.

The procurement department should know the providers of solar water supply systems in the country. The documents can then be send in a focused manner and otherwise through a public bidding process.

23.2. Bids

Bid papers can only be produced after a well has been drilled as the technical details will enable the suppliers to calculate the pump requirements and the panels that can lift the water from that particular depth comfortably. Bid papers must be as accurate as possible as otherwise the response cannot be evaluated properly. At the time that the bid papers are handed over the technical personnel should give their estimates based on experience and on knowledge of systems as well so that the evaluation can be done with the support of number of panels thought to be needed, price of pump and all other components needed from various providers. The technical team should have all documentation already available from the providers identified as being able to respond to the bid.

To contract the cheapest bid should only take place when the estimate is near to and otherwise a further investigation of components offered should be undertaken to understand the costing below expected price. Going for the cheapest bid automatically is a bad decision. The bids should be understood according to information given, quality of products offered, guarantee offered and availability of spares and facilities (visit those that gave a bid by a committee formed to handle the bidding process).

Part of the bidding could be that the providers indicate how long they have been in the business and indicate their expertise, that than needs to be verified.

23.3. Expertise of providers/contractors

The selection of the provider should take into account a number of criteria that should be known before starting the evaluation of the bids. The provider should have local expertise in providing a suitable bid, should have items in stock, should have spares in stock, must have shop/workshop at least in the capital, give a guarantee on the components and installation for three years (preferably), should have their own transport and technicians, should have been in the country for three years and can show some projects done, but especially rely on past experience if not from own organization find others who do have experience.

23.4. Training/ Awareness/ O&M / Follow-up

Awareness creation for managers and training in all aspects for technical personnel would be beneficial for the dissemination of solar systems as per capita the systems can be cost effective especially when taking into account the O&M costs. The provider should be asked if they can provide training for own personnel and the community.

23.5. Experience

An organization wanting to start a solar water supply system should find out through their WASH connections if any systems have been installed by others. Get as much information as possible and look at the market situation and find other potential providers and probe for experience and having trained personnel in installation of the equipment, repair facilities, guarantees, spare parts availability and any other information that would affect the selection of a provider or manufacturer.

24. Lessons learned

24.1. Costing of the system

Costing of systems will depend on the design of the system and a number of other factors as depth of well, distance to reservoir and other factors that will be discussed shortly. The examples that will be used the expectation is that local costs for materials and labour cannot be used in other countries, but cost for equipment imported might indicate costs on an international level depending in so far on the added costs of the local provider. The expectation would be the bigger the turn-over (many systems placed near to each other) the lower the cost. Solar system technology and market is still in its infancy stage and therefore cost recuperation by providers might be higher than in those areas that solar is better established.

The costs for the actual pump with controller can be taken as guideline but included is a spare pump and all the components needed for the installation, from cables, controller and probes. The cost of systems varies widely because of the panel requirement for type of pump, quantity of water needed, depth of well, distance and or height to be pumped and placement of panels (fixed, movable through the seasons or with tracker). A big difference in the cost of borehole can be the cost of drilling, percussion is always a lot cheaper than rotary drilling. Rotary drilling cannot be avoided under conditions that rock formation are present, under such conditions (drilling through rock) the yield might be unsatisfactory.

24.2. The various components to be taken into account

When ordering the system the organization has to prepare the documents carefully and have a full overview of all the components that will make up the system. A provider of systems should be able to give advice but when preparing a bid document the organization has to rely on internal knowledge.

The quality of the products can be a concern and the experience of providers should be taken into account, but providers of equipment can improve their support through training of their personnel. The personnel has followed on-line courses or from a trainer coming down to the country. The provider might be a part of a system whereby the manufacturer has programs ready to support providers with a computerized program to make a selection of all components provided that an initial list of information is provided.

24.3. The provider of the components

Providers of solar water supply systems are at present only located in the capital Kabul. The more systems are built then likely shops will be established in the regions that solar would be likely to be successful even if the design might be done in the capital and providers of the components would be available in the regions.

24.4. Guarantee of the system

A three year guarantee on the system components would need to be demanded while the panels have a 25 year guarantee for the well-known manufactured panels while the system can last for 50 years.

24.5. Spare parts availability

A provider of solar systems without having spares that are recommended by the manufacturer should not be selected for the provision of solar systems.

24.6. Repair facilities

When the provider has no repair facilities or not connected to an able workshop in the repair of solar components such provider should not be selected to provide solar systems.

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