Ministry of Water, Irrigation and Electricity

OPERATION & MAINTENANCE MANUAL

Solar and Wind Energy

Pastoral Area Water Supply

(Volume 3, Parts E, F, G, H)

Solar and Wind Energy, Community and Financial Management of the Pastoral Areas

Document 10

Addis Ababa 2018

FOREWORD and ACKNOWLEDGEMENTS

Her Excellency, Mrs Frenesh Mekuria, State Minister of the Ministry of Water, Irrigation and Electricity

Ethiopia has made great achievements during the last 10 years i providing improved water supply service for its rural population. As a result, Ethiopia achieved the Millennium Development Goal (MDG) target in water supply. The target was achieved mainly through the implementation of small community water supplies. Today the number of these small community water supplies is well over 200,000 and serving a population of 50 million rural people. In order to keep these water supplies operational, the National Rural Water Supply (RWS) Operation and Maintenance Management (O&MM) Manual and Strategic Framework was prepared.

The National RWS O&MM Strategic Framework for Ethiopia is an outcome of collective efforts carried out through a consultative process across the nine regional states by the Federal and Regional Governments and Development Partners (DPs).

I wish to acknowledge the invaluable inputs of Ministry of Water, Irrigation and Electricity staff Regional Water Bureaus, Zone and Woreda Water Offices, Community-Led Accelerated WASH Project (COWASH), Water Action, Action Aid, JICA, World Bank, African Development Bank, DFID, UNICEF, Ethiopian Catholic Church Social & Development Coordination Office of Harar, Millennium WASH Alliance, Ethiopian WASH Alliance, all visited rural piped system Water Boards and Water Administration Offices (WAOs), numerous WASHCO members, user communities and several key individuals who gave freely their time, provided data and information and arranged scheme visits. Special thanks go to Demewoz Consultancy Company in the development of this document.

I would like to underscore the technical and financial support and extensive assistance we received from the Government of Finland financed COWASH project in this strategic framework and manual preparation.

I therefore request that all decision-makers, water technical stall at federal, region, zone, woreda, kebele and community levels secure budget for maintenance management and make sure that continuous improved water supply is provided to all Ethiopians. I believe that this manual will make it possible.

Providing rural water services is irreducibly complicated; there is no single solution for sustainability. Sustainable services rely on an interlocking network of different actors and institutions – all of which need to function at least well enough. Sustainable rural water supply means that whole system from regulation through provision of adequately resourced support services is ensured with accountability.

Addis Ababa in March 2018

Frenesh Mekuria
State Minister

Frenesh Mekuria
State Minister
Ministry of Water, Irrigation and Electricity
Ethiopia

TECHNICAL OPERATION AND MAINTENANCE REQUIREMENTS MANUAL FOR PASTORAL AREAS WATER SUPPLY FACILITIES

Solar and Wind Energy

Pastoral Area Water Supply

(Parts E, F, G, H)

Solar and Wind Energy, Community and Financial Management of the Pastoral Areas

PART – E: SOLAR POWERED PUMPING SYSTEM

Document 10

Solar and Wind Energy and Pastoral Area WS

Solar and Wind Energy, Community and Financial Management of Pastoral Areas

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PART – E: SOLAR POWERED PUMPING SYSTEM

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5. SOLAR POWERED PUMPING SYSTEM

5.1 General

The solar pumping system serves to provide water in remote applications where electrical grid power is either unreliable or unavailable. The system pumps water using a high-voltage DC power source such as a photovoltaic array of solar panels (which is abbreviated as solar array in this manual). Since the sun is only available during certain hours of a day and only in good weather conditions, the water is generally pumped into a service reservoir or tank for further usage, and water sources are those natural or special such as groundwater, river, lake, impounding reservoir, etc. Two level switches, one is High Level Switch, the other is Low Level Switch, should be installed inside the service reservoir or tank to regulate the water level. If the water comes from a well, another two level switches should be installed inside the well. The Low Level Switch of the well serves as an indication that the well has run dry. The system will shut down to protect the pump and motor until the well has recovered as the High Level Switch is reached by water.

5.2 What makes up a Solar Power System?

Many people are just learning about the industry, and don't realize that there is more to a solar system than a panel and some cabling. This is a basic guideline to give you an idea of what you need to make a system work for you.

5.3 Building a Solar System

The first and most obvious component in the solar setup is the array of panels. An important point with solar panels is that the voltage is always higher than 12V (usually around 17.5V). When you work out your panel requirement you must use the amperage rating, not wattage, as the higher voltage means lower amperage and therefore the wattage can be misleading. You should always check the specifications when buying solar panels. Example: A 100W, '12V' panel is actually 17,5V. The amperage this panel will give out is not 100W/12V, but rather 100W/17.5V = 5.7 amps.

Your next component is the charge controller, also known as the regulator. Solar regulators are different to ones used for wind power. There are hundreds of different types of regulators with sizes ranging from 5 Amps to 80 Amps. You also get different types; the normal, straight-forward regulator which is great for smaller loads, and the MPPT regulator which adds about 20% efficiency to the system and is used for bigger systems. The regulator size requirement is determined by the amount of energy supplied by the panels. The rating of the regulator is how much energy it can handle per hour. Example: A 60 amp controller will handle 60 amps per hour. Any energy in excess of that rating (in this case 60 amps) will be wasted, therefore it is important that you don't undersize your regulator.

Next, you need batteries; there are many different makes and types available. Normal marine deep cycle batteries are more commonly used for smaller systems, while the special high amperage solar batteries are ideal for larger installations. Normal car

batteries will not perform well with solar power systems because of their shorter life spans. It is a bad idea to draw all the energy out of the batteries. We give them 50% depth of depletion, to prevent damage and lengthen their life span. Example: With a battery of 105 amp hours, we work on 50 amp hours of useable storage.

An inverter is the final step in your basic solar system (before the distribution board). Solar setups are always DC (12V, 24V, 36V or 48V). What the inverter does is it converts the DC voltage into AC voltage to run your normal everyday appliances. You get appliances with 12V configurations nowadays, which allow for a direct connection from the batteries to the appliances or db board, cutting out the need for an inverter. The inverter size is determined by the peak amount of energy your load can draw at any one time. For safety, you should add 20% to the inverter requirement. Example: If you're powering 5 lights of 20W each, your inverter needs to be 5 x 20W (+20%) = 120W.

Cabling, lugs, switches and connection boxes are smaller, yet essential components. The quantities are determined by the size of your system, the number of connections and the distances between components. With a 12V system, it is advisable to keep the panels and batteries within 10m of each other. The regulator and inverter should both be placed near the battery bank. The cable thickness is determined by the size of your system and the distance that the energy will travel. If you're using a 12V, 1000W system with a distance of 10m, you need 10-12mm cabling. If the cabling is wrong, the system will under-perform or even burn the wiring.

The voltage of a system is determined by the amount of energy running through it. Anything up to 2000W can be run through 12V; from 2000W to around 5000W can be run through a 24V system; and from 5000W up to around 20 000W, a 48V system should be used. Anything higher needs 240V.

It is also a good idea to get a combiner box, which allows you to plug all of the wires from your panels into one box, with a single wire coming out from the other end. This just neatens the system and makes it more manageable for installation, maintenance and upgrades.

It is highly recommended that fuses be included in larger systems, as they prevent short circuits from happening. If the wiring has been damaged somehow and the positive and negative wires touch, a short circuit will occur, and could potentially start a fire or even cause the battery to explode.

Diodes allow the current to run in one direction only, **like a valve**, preventing the energy from running back into the panels from the battery bank. If this occurs, it can damage the panels, particularly with more powerful batteries.

5.4 Components of Solar Energy System

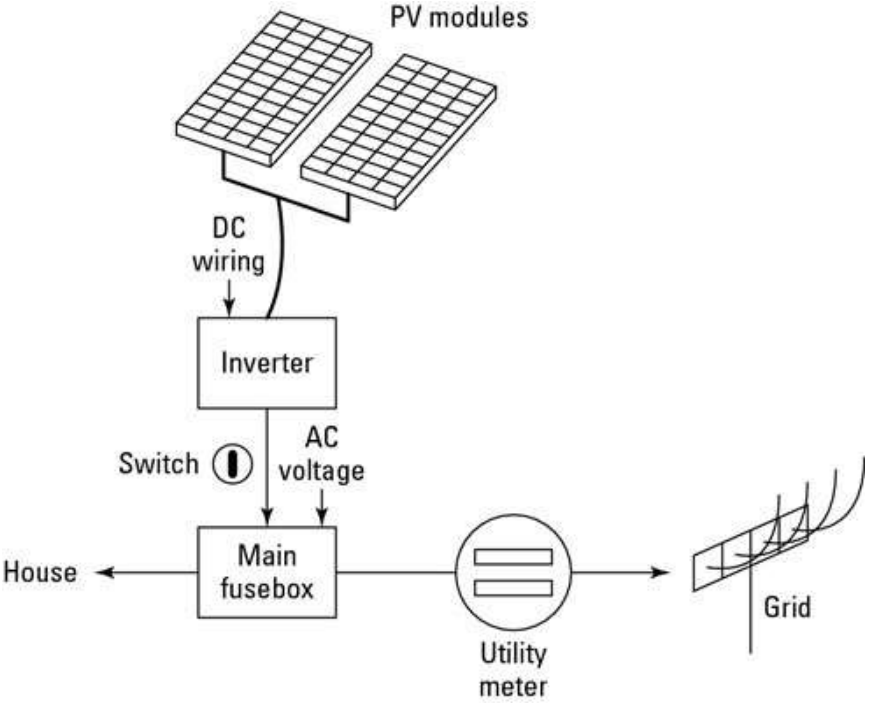
Interconnected solar cells, which convert sunlight directly into electricity, form a solar panel or “module,” and several modules connected together electrically form an array. Most people picture a solar electric system as simply the solar array, but a complete system consists of several other components. The various main components of the solar energy system is presented in Figure 5.1.

- An inverter converts the direct current (DC) electricity produced by the modules into alternating current (AC) electricity for powering lights, appliances, and other needs.
- Wiring connects the various components of a solar electric system. In some cases, the system is also interconnected to the power grid.

- Batteries are used to store solar-produced electricity for night-time or emergency backup power. Batteries may be required in locations that have limited access to power lines, as in some remote or rural areas.
- If batteries are part of the system, a charge controller is included to protect them from being overcharged or drawn down too low.
- Finally, disconnect switches allow the power from a solar electric system to be turned off to provide safety during maintenance or emergencies.

Most providers of solar electric technologies can supply you with all the components you will need for a fully functional system.

Figure 5-1: Components of Solar Energy System



5.5 Operation Maintenance Procedures

5.5.1 Modes of Operation

The operational modes for a solar energy system can be described as automatic, manual, and layup. The conditions required to initiate the particular mode, and the status of the components affected by the mode, are listed in the control mode. The corresponding control schematic shows the physical relationship of the various control components.

The operation section of the O&M manual includes a mode matrix and a control schematic that describe all possible operational modes for the specific system. They are normally provided with the construction specification and may be incorporated into the O&M Manual.

- **The automatic mode** is the normal operating mode for the solar energy system. No operator action is required in this mode when the differential temperature controller (DTC) is in the "automatic" position. The system will start, operate, and shut down automatically when the control parameters described in the control mode matrix are reached. System protection actions are also carried out automatically.

A simple checklist should be completed regularly by the operator to confirm that the solar energy system is operating normally.

- **Manual operation** of the solar systems is defined as operation of part or all of the system without automatic controls. Manual operation is primarily used for trouble shooting and performance testing. Diagnosing malfunctions requires the separate operation of individual components to isolate the fault and correct the malfunction. Performance testing may require the individual operation of components instead of the whole system.

5.5.2 Start-up

This mode should never be tried without following a specific operating procedure prepared by the solar energy system designer to take care of the specific system problem.

Prior to manual start-up of a system, certain precautions must be taken, beginning with a review of the operation control mode matrix, then proceeding as outlined below.

1. Verify that the system is not shut down due to some automatic protection mode. For example, if the system were shut down during the automatic operator when it is started manually the system may be damaged.
2. Verify that there is fluid in a liquid system so the pumps are not operated dry. Check the fluid levels in the system against the design requirements.
3. Verify that all manual valves are in their proper position. Review the Piping and Instrumentation Diagram (P&ID) and control schematic to see the valves position requirements.
4. Verify that no personnel are close to pressure relief valves or evacuated collectors at start-up. These are the most likely components to be affected by a pressure surge at start-up.

The operator must closely follow system performance during manual operation. The operator should stay with the system during start-up, check the system periodically and stop when the reservoir is full.

Manual test operations may involve individual component, subsystem, or system functions. Typically, pumps are operated individually to check the flow rate and pressure rise. Valves are operated to check for leakage and capability to function in either the fully open or fully closed positions.

5.5.3 Leaks

Once a leak is discovered, immediate action is essential to keep damage from the leak to a minimum:

Locate the exact source of the leak. Shut down system pumps. Shut off makeup water supply, reducing system pressure at the leak. Isolate the leaking component with the closest block valves.

Once the leak is stopped and system safety is secured, fix the leak and its damage as soon as possible, following the repair/replace procedures. If the repair process is going to take some time, it may be possible to isolate the leaking section and operate the solar system.

5.5.4 Maintenance Personnel Training

Maintenance personnel training is required if the maintenance and operating personnel are not one and the same. This training should be identical to the operator training discussed. Operating and maintenance personnel should understand both operational and maintenance procedures of the solar energy system.

5.5.5 Preventive Maintenance

Preventive maintenance is required in solar energy systems, as in other systems, to maintain an optimum level of performance and to extend the life of the system. Preventive maintenance should be performed on a regular schedule and should include a visual inspection and routine major component maintenance.

The visual inspection should be performed every two or three months using a checklist tailored for the specific system. A sample detailed visual inspection checklist is shown in Annex-A. It includes a sample maintenance record form that may be used to report a full year's inspection data. The completed checklist and form become part of the system's permanent maintenance record.

The major components of a solar energy system include the water fluid, pumps, storage tanks, filters, valves, piping systems, and instrumentation and controls. Each component can have specific maintenance requirements from the manufacturer that become part of the maintenance manual.

5.5.6 Submersible pump

Submersible pumps used in solar energy systems are fluid-or self-lubricated and require basically no maintenance.

Additional periodic maintenance checks for pumps include differential pressure across the pump, and pump or motor temperature. The differential pressure across the pump, when operating, should be in the range of the value when first installed. The pump should not be unusually noisy or hot.

Measure the current drawn by the pump in normal operation and check against that measured at installation; higher amps could indicate trouble. Clean out strainers installed upstream of pumps regularly.

Installation

General Information NOTICE: The Model Number of your pump is located on the top portion of the pump shell. Record this number along with all pumps installation data and keep it in a safe place for future reference, in the event servicing is required. The most important things you should know about your well are:

1. Well total depth- the distance from the ground level to the bottom of the well.
2. Depth to water- measured from the ground level to the water level in the well when the pump is not in operation.
3. Draw down water level- the distance from ground level to the water while water is being pumped from the well. In most wells, the water level drops when water is being pumped.

4. Well capacity (m^3 /h)- the amount of water in m^3 /h the well produces without drawing down or water level dropping.

Cable Splicing Methods: When the drop cable must be spliced or connected to the motor leads, it is necessary that the splice be water tight. The splice can be made with commercially available potting or heat shrink splicing kits. Follow the kit instructions carefully.

1. Heat Shrink Tubing Method - RECOMMENDED METHOD (Kit Order #60333 - 3 wire pumps; #60332 - 2 wire pumps)
   a) Strip about 1/2" of installation from cable and lead ends.
   b) Slide about 3" long heat shrinks tubing over the cables.
   c) Connect cable and lead ends with STAKON or similar connectors
   d) Position the tubing over the connection keeping the connector at its center.
   e) Apply heat (about 135°C) evenly on the tubing and working from center outwards to avoid trapping air. While heated, the adhesive liner seals the interfaces between the tubing and the connector cable. Perfect sealing is achieved when adhesive liner flows outside the tubing and seals the ends. While heating, care must be taken not to overheat the cable outside the tubing. This will damage the insulation of the cable.
2. Tape Method (Alternative) SPLICING SUBMERSIBLE CABLES WITH TAPE, Tape splicing should use the following procedure.
   a) Strip individual conductor of insulation only as far as necessary to provide room for a stake type connector. Tubular connectors of the staked type are preferred. "STA-KON" Connector.
   b) Tape individual joints with approved rubber electrical tape, using two layers; the first extending tow inches beyond each end of the conductor insulation end, the second layer two inches beyond the ends of the first layer. Wrap tightly, eliminating air spaces as much as possible.
   c) Tape over the rubber electrical tape with approved PVC electrical tape, or equivalent, using two layers as in step "2" and making each layer overlap the end of the preceding layer by at least two inches. In the case of a cable with three or four conductors encased in a single outer sheath, tape individual conductors as described, staggering joints. Total thickness of the tape should be no less than the thickness of the conductor insulation.

The following test is recommended before installation. Cable and splice test for leaks to ground.

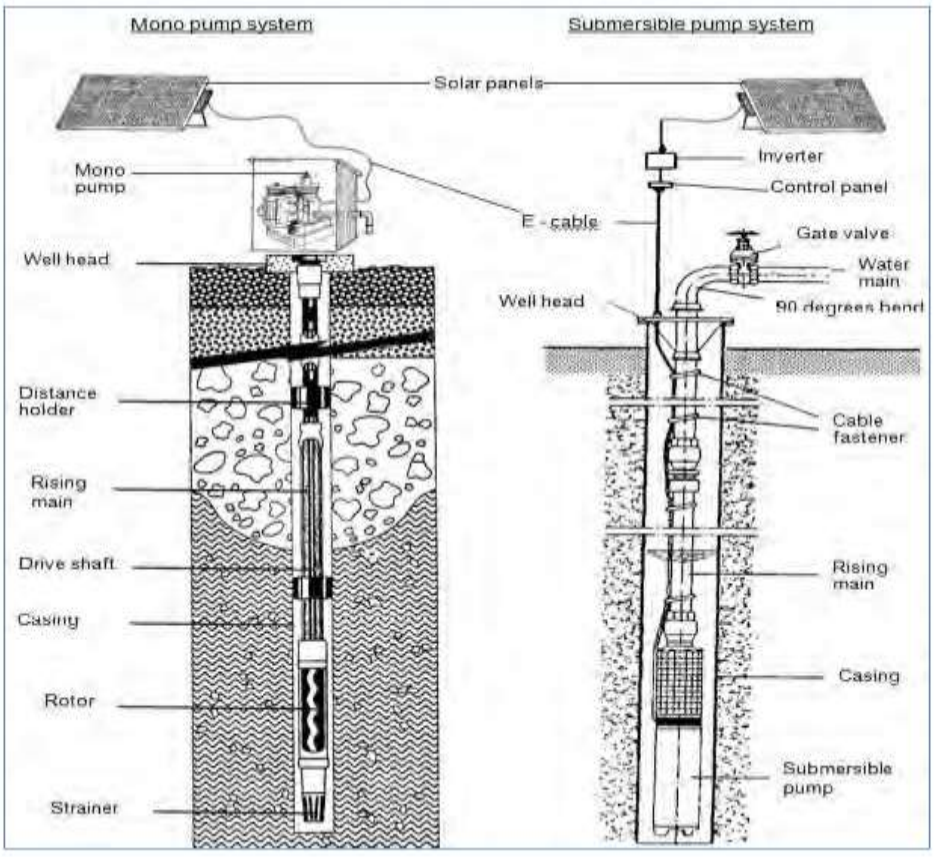
1. Immerse the cable and splice connections into a steel barrel of water with both ends out of the water and not touching the barrel.
2. Set ohmmeter on RX 100K and adjust needle to zero (0) with leads clipped together.
3. Clip one ohmmeter lead to the barrel and the other to each cable lead individually.
4. If the needle deflects to zero (0) on any of the cable leads, a faulty splice connection is indicated. To double check the faulty splice connection, pull the splice out of the water. If the needle now moves to $\propto$ (infinite resistance) the leak is in the splice.
5. Repairs should be made with approved electrical Rubber & PVC tape.

6. If the leak is not in the splice, pull the cable out of the water slowly until the needle moves to ∝.When the needle moves to ∝ the leak is at that point.

Installing Your Pump PUMPLOCATION Your submersible pump should be installed no less than 5 feet (1.5 meters) from the bottom of your well.

Solar energy system with the groundwater is presented in Figure 5.2.

Figure 5-2: Solar Energy System with the Groundwater



A solar-direct pump should start under the following conditions:

Box 5-1: Conditions for start of solar-direct pump

1. Clear sunshine at an angle of about 20° or more from the surface of the solar array,
2. Cloudy conditions, if the sunshine is bright enough to cast some shadow,
3. low-water probe submersed in the water source (or bypassed in the controller) – Water-Low light OFF,
4. full-tank float switch is not responding to a full tank – Tank-Full light OFF,
5. Battery system only – voltage is higher than the low- voltage disconnects point (22V or 44V).

CAUTION: To avoid accidental loss of the pump in the well, it is recommended that a 1/4" polypropylene rope be permanently attached to the eye provided on the discharge head of

the pump. The other end of the polypropylene rope should be secured to an anchor at the well head.

5.5.7 Control Unit(s)

Controller: The controller functions to control the charge on the batteries. The controller is a solid state device which control the charging and discharging of the batteries. The controller provides temperature compensated charging so that the rate of charge is controlled for both temperature and state of charge. The controller will shut off charging when the battery reaches a charge of 15.2 VDC. The controller will disconnect the load when the battery voltage reaches 11.4 VDC. These set points have been established to prevent damage to the battery from an overcharge condition or a low voltage condition. The controller also has a manual disconnect switch that allows you to electrically disconnect the batteries from the system.

The controller provides a LCD display that cycle through a display of battery voltage, array current, and load current. Flasher: The flasher is a 12/24V DC, solid state flasher that consumes negligible power during operation. The flasher is set at the factory to provide 50 flashes per minute, for 1 or 2 circuit operation (depending on your system configuration), LED or Halogen (depending on your system configuration), and a 50% duty cycle. Battery: The battery stores the electrical energy which powers the load. Batteries are maintenance free sealed gel, absorbed mat technology. If your system is 'knocked down' by accident and your battery punctured, you will experience little to no acid spilled due to the absorbed mat technology.

Time Clock: The time clock is a solid state programmable device which will control the operation of your load based on the program you enter in the time clock. The time clock automatically compensates for daylight savings time and leap year. The daylight savings time feature can be disabled at the user's discretion. The time clock is rated at 15 amps per circuit and operates on 12V DC. The time clock usually has one relay but may come with 2 or 4 relays if the end user has requested a clock with 2 or 4 relays powered flashing beacon systems use LEDs.

Terminal Block: Normally all components are pre-wired with circular connectors for ease of component replacement. However if your system is being used to power loads other than beacons, a terminal block will be provided to facilitate termination for the load. The power terminals will be clearly identified as to positive (+) or negative (-). All Texas approved solar systems will have terminal blocks.

Connecting Battery(s): Warning: Remove the battery fuse in the battery cabinet prior to connecting the battery(s).

If you have been provided with more than one battery, you will also have red and black jumpers with ring terminals to connect the batteries in parallel. Unscrew the wing nuts from the battery terminals and attach the rings to the battery connection. The red jumper goes to the positive terminal and the black jumper goes to the negative terminal.

Thread the black and red 10 AWG ‘red and black wires of the ‘backbone’ harness through the hole in back left corner of the control compartment in the battery cabinet. These wires should have rings on the ends of them. Unscrew the wing nuts off the battery terminals and attach the red wire to the positive terminal of the battery and the black wire to the negative terminal of the battery.

5.5.8 Solar panels (photovoltaic modules)

Sunlight is converted by the solar panels to electrical energy while the batteries store the electrical energy. The solar panels are connected to the batteries through a controller which controls the charging and discharging rate of the batteries. The time clock controls the time and duration that power is applied to the load. If the system is a 24 hour flashing beacon system, then no time clock will be in the system. The flasher is a solid state, 12/24 volt DC flasher that switches the power from one beacon to the other. If the load is not a flashing beacon system, then no flasher is provided with the system.

The load is always powered from the batteries via the controller, never from the solar panels directly. Solar Panel(s): The solar panel(s) are off the shelf items, warranted for 20 years. As noted above, the panels convert sunlight to electrical energy to charge the batteries. A single panel will usually be from 40 - 130 watts. Depending on your system requirements you may have multiple panels.

Final Connections and System Checkout:

You should perform several quick checks to ensure that your wires and connections have been made correctly.

After you have made your wire and connections checks, connect the 'backbone' harness assembly from the solar panels and battery to the large circular connector on the back of the control panel. Re-install all fuses. There are 3 fuses, the load fuse, the battery fuse, and the solar panel fuse.

The controller should have at least 1 LED lit, indicating that battery voltage is present at the controller. If all wiring has been made correctly, LEDs will light on the controller.

You will see the LCD display cycling through the parameters it displays. You should see battery voltage with a reading greater than 11.4 volts, array current, and load current. You will have to wait 2 minutes after system initialization before the load current is displayed. If the load is not turned on, the reading will be 0.0 amps.

If you system has a time clock, you should also see the display on the time clock lighted. The clock should be cycling through several displays which show date, time, relays on (or off), and program running. If you have 'power fail' showing on your time clock, simply push the button on the key pad marked 'C'. This should reset the time clock. *(Refer Annex- A).*

These have no moving parts and there is very little that technically can go wrong with them. Consequently many of them have a 20 year manufacturer’s guarantee. The main risk to the panels is from theft, vandalism or children throwing stones which cause damage. Theft in particular is a major problem in most areas, so Water Administration Service/WASHCOs need to ensure thorough security measures are in place to minimize these threat and panels are well secured.

Maintenance tasks include:

- Clean solar panels weekly if they are covered with dust (in very dusty areas clean twice a week using a wet cloth)

- Protect the fragile solar panels (panels and solar pump within a fenced enclosure of 40 m radius for protection and therefore the fence requires to be kept in good condition and the gate should be safely secured).

- When carrying out any servicing of this equipment ensure the right qualified personnel do the work.

Typical output ratings of panels are show in Table 5.1.

Table 5-1: Typical output rating of panels

Panel Rating (Watt)	I - Typical	V - Typical	I - Short Circuit	V - Open Circuit
30	1.78	16.8	1.94	21.0
40	2.37	16.8	2.58	21.0
50	2.97	16.8	3.23	21.0
55	3.33	16.8	3.69	21.0
60	3.56	16.8	3.87	21.0
65	3.77	16.8	4.06	21.0
70	4.14	16.8	4.35	21.0
75	4.54	16.8	4.97	21.0
80	4.75	16.8	5.17	21.0
85	4.97	16.8	5.3	21.0

5.5.9 Motors

A solar water pumping system consists of four main parts: the pump set with motor, pump controller, the solar electric panels and a storage unit.

The pumping systems are broadly configured into five types, namely:

- Submerged borehole/ multistage centrifugal motor pump set,
- Submerged pump with surface mounted motor,
- Reciprocating positive displacement pump,
- Floating motor pump sets and
- Surface suction pump sets

Among the above-mentioned systems, submerged multistage centrifugal motor pump set is probably the most common type of solar pump used for rural water supply. The advantages of this configuration are that it is easy to install, often with lay-flat flexible pipe work and the motor pump set is submerged away from potential damage. Either AC or DC motors can be incorporated into the pump set although an inverter would be needed for ac systems. If a brushed dc motor is used then the equipment will need to be pulled up from the well (approximately every 2 years) to replace brushes. If brushless dc motors are incorporated then electronic commutation will be required. The most commonly employed system consists of an AC pump and inverter.

Some DC motors need replacement brushes; this is usually a simple operation (far simpler than, e.g. servicing a small engine powered pump).

Brushes will probably need to be replaced after two years of operation.

Table 5-2: Motor Circuit Breaker or Fuse Requirement

Rating			Wire	Fuse	Circuit Breakers of Fuse Amps					
HP	KW	Volt			(Maximum Per NEC)			(Typical Submersible)		
					Standard Fuse	Dual Element Time Delay Fuse	Circuit Breaker	Standard Fuse	Dual Element Time Delay Fuse	Circuit Breaker
½	0.37	115	2	1	35	20	30	30	15	30
½	0.37	230	2	1	20	10	15	15	8	15
¾	0.55	230	2	1	25	15	20	20	10	20
1	0.75	230	2	1	30	20	25	25	11	25
1.5	1.1	230	2	1	35	20	30	35	15	30
½	0.37	230	3	1	35	20	30	30	15	30
½	0.37	115	3	1	20	10	15	15	8	15
¾	0.55	230	3	1	25	15	20	20	10	20
1	0.75	230	3	1	30	20	25	25	11	25
1.5	1.1	230	3	1	35	20	30	30	15	30
2	1.5	230	3	1	30	20	25	30	15	25
3	2.2	230	3	1	45	30	40	45	20	40
5	3.7	230	3	1	80	45	60	70	30	60
7.5	5.5	230	3	3	80	45	60	70	30	60
7.5	5.5	575	3	3	30	20	25	30	12	25
7.5	5.5	460	3	3	40	25	30	35	15	30
10	7.5	575	3	3	45	25	35	40	20	35
10	7.5	460	3	3	60	30	45	50	25	45

5.5.10 Inverter (AC) Automatic/Regulator (DC)

Inverter: On rare occasion, the end user may need to power a 120/24V AC load. If you have specified a requirement for AC power, your system will have an inverter installed.

Maintenance:

The system does not have any moving parts and therefore requires only minimal maintenance. The system owner should periodically (e.g. monthly) check that the system is still operating, this can be most easily done by either:

- Checking that all inverters are operating (the green light is on in good weather conditions),
- Visual display shows an increased value over a period of a day.

The most common explanation for complaints about system performance can be traced to the system being accidentally turned off.

It is recommended that the system is thoroughly checked at least once a year, to ensure that it remains in good working order and operating as expected.

a) Yearly check Table

The checks shown below should be made each year by suitably qualified personnel using calibrated test equipment, preferably during the summer months and compared to

previous results. Judgment is required to interpret test results in relation to weather conditions. The yearly maintenance that needs to be checked is presented in Table 5.3.

Table 5-3: Annual System Maintenance checks

Check	Method for testing	Expected value	Possible reason for error
Inverter power output	Each inverter indicates AC power on its display. The irradiance must be measured in order to estimate the expected value.	At STC1 Inv: 0.7 kW (nominal)	Inverter or PV array fault – continue with further checks to determine cause of fault.
Inverter loss of mains	Isolate the AC isolator to disconnect the inverter from the mains.	Inverter indicates error (loss of mains)	If inverter does not indicate error, inverter is faulty.
String open-circuit voltages	Leave inverter isolated from mains. Isolate the inverter from the PV array using the DC isolator. Disconnect the string from the inverter. Measure Voc.	See table 4 for Voc values at STC[2]	Faulty PV module, connection or DC isolator.
String short-circuit currents	Method as for Voc, but measure Isc. Take care when making the short circuit.	See table 4 for Isc values at STC[2]	Faulty PV module, connection or DC isolator.
Correct inverter operation 1	If all above measurements are correct, re-connect the PV array to the inverter and close the DC isolators.	Inverter lights may flash but should not indicate generation.	If inverter indicates it is generating (yellow light blinking), it is faulty.
Correct inverter operation 2	Re-connect the inverter to the mains by closing the AC isolator.	Inverter orange light for 180s, then green light constantly.	If there is sufficient daylight and the yellow Led is not blinking after five minutes, the inverter is faulty.
Wear and tear	Examine all internal cabling and isolators for visible signs of damage or wear and tear. Replace any faulty equipment.		

b) Five-year check Table

It is recommended that the checks detailed in Table 5-4 are undertaken on a 5-yearly basis. When undertaking a detailed inspection and cleaning of the roof mounted array, appropriate notice should be taken by staff and due consideration should be made of the need for appropriate roof access equipment to be used. A further maintenance schedule should be determined when this first extended check has been carried out.

Table 5-4: Periodic System Maintenance checks

Check	Method for checking	Action to be taken
Mounting system	Check for wear and damage	Replace any missing or damaged fitments
PV modules	Examination of all PV modules for damage or signs of wear and tear	Replace any severely damaged modules if they are no longer weatherproof
Cabling	Check integrity of all cabling and for any signs of damage	Replace any damaged cabling
Cleaning	N/A	Laminates should be cleaned using water/ mild detergent as used for window cleaning

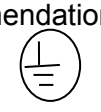
5.5.11 Wires

Wiring terminals are different in shapes and combinations, depending on different sizes of solar pump controller. Terminals Arrangement of solar pump controller Capacitors inside the solar pump controller can still hold lethal voltage even after power has been disconnected. Allow five minutes for dangerous internal voltage to discharge before removing solar pump controller cover to access the terminal.

Power-In DC Wiring For Solar Pumping Systems, a two-pole DC disconnect switch must be installed between the solar array and the solar pump controller. Connect the cables which comes from the two-pole DC disconnect Switch downstream terminals marked with "+" and "-" (positive and negative poles of Solar panel output), to solar pump controller's terminals block labelled as "R", "T".

Before connect DC wiring, the following steps are need to be followed to prevent hazardous electric shock resulting in serious injury or device burning.

- Make sure that the external DC disconnect switch is off.
- Make sure that AC power is disconnected (if AC power supply is wired as backup power)
- Make sure that all wires are properly identified and marked:
  a) The cable from the PV to the external DC disconnect switch
  b) The cable from the external DC disconnect to the solar pump controller

Do not connect a solar array directly to the DC input of the solar pump controller without protection such as DC disconnect switch. In this controller, the integral solid state short circuit protection of motor wiring does not provide circuit protection of wiring for input power. Input wiring protection must be provided in accordance with all applicable national and local electrical codes. In addition, follow any manufacturer's recommendations for protection of a photovoltaic (PV) array and protection of a generator, if used. 

Ground Wiring:

Ground terminal (GND) is labelled as this icon.  Please refer to the instruction to this icon, or other equivalent icon or sign by local electrical codes or international standard. Connect the ground wire to the ground terminal of solar pump controller. Correct Grounding helps to prevent shock hazard if there is a fault in the motor.

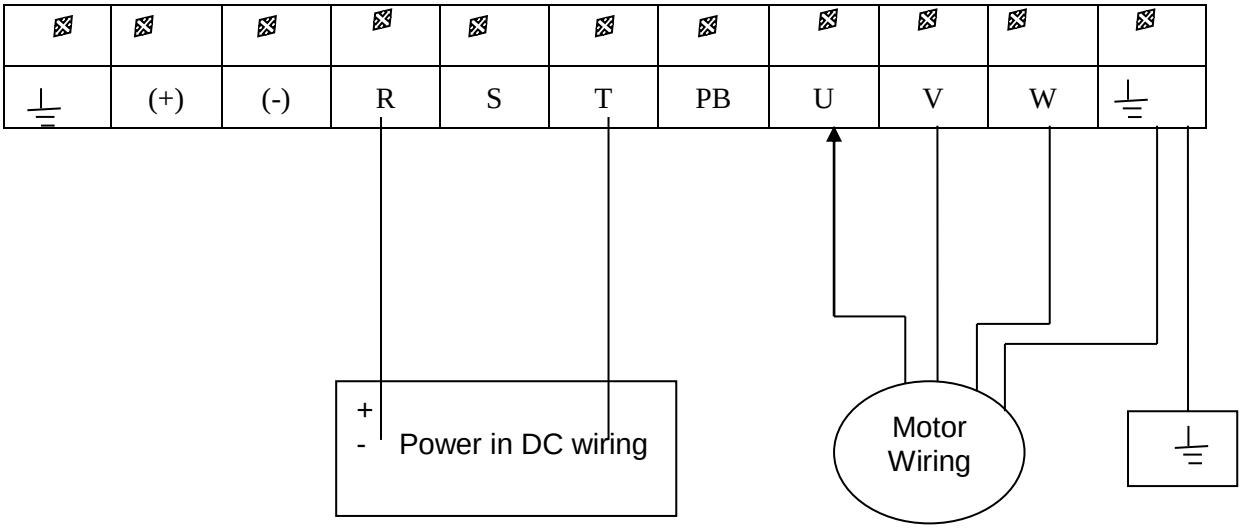
Serious or fatal electrical shock may result from failure to connect the ground terminal to the motor, the solar pump controller, metal plumbing and all other metal near the motor, or cable to a proper earth ground in accordance with local codes, using wire no smaller than motor cable wires. To minimize risk of electrical shock, disconnect power before working on or around the solar pumping system. Do not use motor in swimming areas.

Motor Wiring:

Connect the cable with four wires from the Motor to the controller terminal block to terminals U, V, W, and GND (See Figure 5-3). (Do not over-tighten the screws.).Motors with international leads are as shown in the table in Figure below. Check motor lead colour to ensure correct installation. Note: To reverse direction of motor rotation, reverse any two wires.

US	Black (BLK)	Red (RED)	Yellow (YEL)	Ground (GND)
International	Gray (GRY)	Black (BLK)	Brown (BRN)	Ground (GND)

Figure 5-3: Motors wiring with International leads



Main Terminals Wiring

5.5.12 Pulleys and Belts

Belt gearing with V-belts guarantee quiet, calm and smooth operation. Its advantage is a possibility to smooth sudden load changes as well as damping of vibrations. Simple and cheap construction do not require special service and special maintenance what reduce costs of operation. Used up V-belts can be quickly and easily exchanged without prolongation of machine downtime.

Factors influencing belt durability:

a) Number of belts in one set

Belt gearing is designed for optimal number of used belts. If the number of belts in one set decrease, lifetime of remain belts lowers disproportionately. If for example: according to calculations drive requires usage of 10 belts, and if one belt will be removed, lifetime of remain belts decreases not by 10% but by 30%

b) Belts tension

For excellent drive transferring and for reaching required belts durability a very important factor is to ensure correct belts tension. Belts should be tensioned as appearing slippage at the pulley not exceed 1%. Too small tension causes excessive belts slippage at belt pulley; too big tension – decrease belt lifetime as well as quicker bearings wear in propulsion machinery and driven machinery.

c) Correct belt pulley selection

Important factor of reliability and equal operation of V-belts is exact fulfilling of conditions specified for belt pulleys:

- belts should work at grooved pulleys of dimensions fitted to belt section, as only side (working) walls of belt were in contact with walls of pulley grooves;
- Pulley grooves should be smooth, without deformations, snagging and contaminations, particularly grease and oils. Surface coincides of groove pulleys should not be painted

d) Usage of tension rollers.

In a gearing, where is not possible to strain a belt by changing a distance between driving machine and driven machine, a tension roller can be used for belt tension. Other phenomenon, which require usage of tension roller are vibration of long belt tie rod of small tension or short tie rod during rapid load changes. Each usage of rollers increase frequency of belt inflection and introduce additional bending stresses that shorten its lifetime.

e) Cleanliness

Belt gearing is sensitive for chemical influence of environment, its temperature and humidity, as well as lubricants and pollutions. In case a gearing operate in an environment of increased pollution, then it should be protected by special covers. Power bands require special protection from environmental pollution. Oils and lubricants cause decreasing of coupling between belt and pulley as well chemically affect at belt causing its quick destruction.

f) Storage of belts

Properly stored V-belts do not lose their properties rods for years. Rubber products stored in adverse conditions together with bad handling change physical properties. These changes are caused by influence of oxygen, ozone, extremely unfavourable temperatures, light, humidity or solvents.

Solar tracking

This innovative technology enables several rows of solar panels to follow the sun thanks to a single lightweight but precise master control system which uses a low driving force.

The amount of energy produced by the solar panels is directly dependent on the intensity of the sun’s rays picked up by the receiver. In the case of a fixed panel, this intensity varies over the day. The tracking system enables the unit to optimize the amount of solar energy collected, and thus to increase its efficiency. However, classical solar tracking

technologies are complex, relatively unreliable and involve a great amount of maintenance.

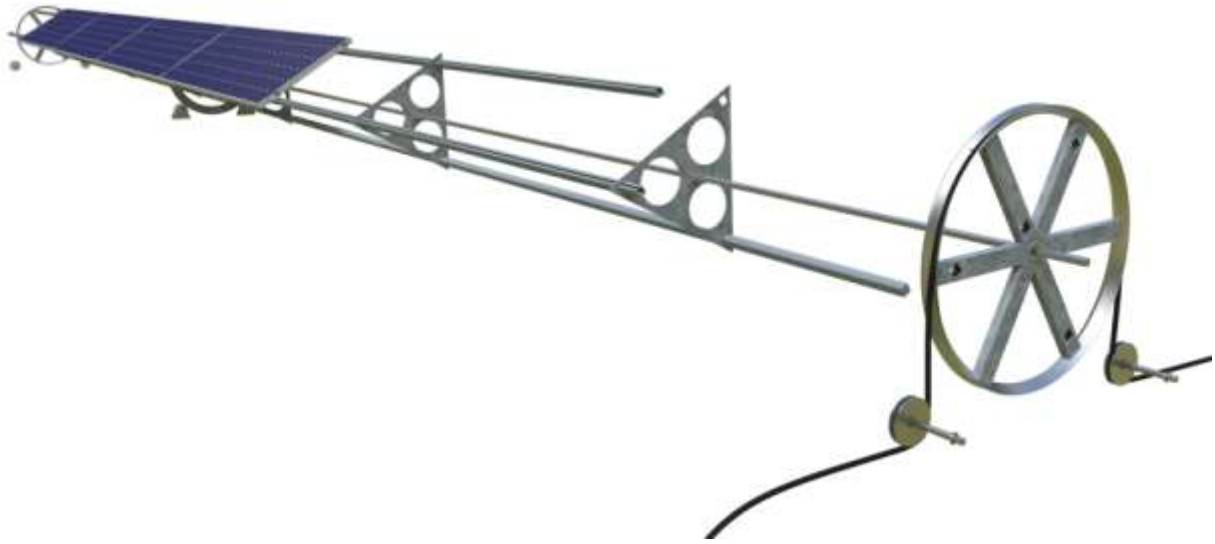
Description

Our patented technology enables rows of panels to move together in a coherent and precise way. The technology can be applied to both types of solar panels (photo-voltaic and thermal) and also to mirrors in the case of a solar power station. This solar tracking technology operates thanks to a foundation frame, rotating frames, interconnecting cables and a control system.

1. Foundation frame

A supporting frame is fixed onto a limited number of foundation blocks. Once the frame is in place, it takes the weight and fixes the whole of the structure above it – the rotating frames which carry the weight of the panels, the tracking driving and control systems.

2. Rotating frames



Each rotating frame is constructed around a central rotating axis within a frame providing the necessary rigidity and with a pulley at each end. This solid structure can then rotate easily on its axis. The frame supports a row of panels.

3. Interconnecting cables

The rotating frames are interconnected via a unique system of cables fixed to driving pulleys at each end.

4. Control system

A driving force winds and unwinds the cable, thus producing a simultaneous angular movement of all the rotating frames. The control system ensures the rotating angle corresponds to the movement of the sun.

Recent solar trackers like iPV do not use pulley and belt but use another mechanism to adjust the solar panel towards the sun as discussed below.

iPV Solar Tracker Features

“This is the unique solar tracker and it has already acquired numerous invention patents in EU, Japan, USA, China and etc.

There are many mechanisms to drive solar trackers. The most common one is a pair of dual solar wheel axes which allows rotation up to around 270 degrees. Topper Sun’s iPV Solar Tracker adopts a unique universal axis design that couples with affordable and stable steel cable pulley system. It is the first solar tracker in the world that can rotate 360 degrees (elevation angle of 40-130 degrees). Its “dynamic balancing” structure moves similarly to an elevator or a seesaw -- the four corners of the solar panel platform are secured and strengthened by steel cables and the structural flexibility is enhanced by shock springs that are fixed to the ground. Each iPV Solar Tracker is equipped with a calendar program that calculates the sun’s orbit. By simply setting the latitude and longitude of the location, the system will automatically adjust its angles every five minutes to track the sunlight. Accordingly, the iPV Solar Tracking system is so simple that energy consumption and maintenance costs are very low.

For Maintenance of pulley Refer Annex- H

5.5.13 Exposed terminals (on panels or inverter)

Exposed terminals are the source of danger and injuries to unman body and can cause fire to the neighbouring equipment. Every terminal shall be insulated or caped properly if it is not connected to its destination.

The following precondition shall be met to avoid exposed terminals from the system

- All cables leading to the controller must be disconnected from the power supply and it must be ensured that they cannot be unintentionally reconnected during installation.
- Each connection terminal must only be connected to a single conductor.
- The protective earth conductors (PE) from the mains cable and pump and valve cables must be connected to the protective earth conductor terminal block.
- All cables must be laid so that persons cannot stand on them or trip over them.
- The local power supply must match the specifications on the type plate of the controller.
- The power supply cable is to be connected to the mains power as follows: –
    - using a plug connected to a wall mains socket or
    - Via an isolating mechanism allowing complete isolation in the case of permanent wiring.
- The power supply cable must be laid in conformance to all applicable legal guide- lines and regulations of the local electricity supplier.

5.6 Non-Routine Maintenance / Troubleshooting

5.6.1 Diagnostics and Troubleshooting

The solar pump controller will attempt to drive the pump to deliver water even under adverse conditions. To ensure years of reliable service, it must also protect the system components from conditions that might result in equipment damage. When adverse conditions arise, the controller will continue to deliver as much water as possible at reduced output if necessary, and will shut down only in extreme cases. Full operation will resume automatically whenever abnormal conditions subside. Error conditions may suspend certain features, reduce output, or shut down operation of the controller for varying amounts of time depending on the nature and severity of the error. Problems that merely reduce features or performance generally restore full operation when the trouble condition subsides without stopping the pump or flashing an error code. A severe error such as short circuit or over current requires stopping the motor immediately. An overload error stops the controller with a delay by time-load curves defined internally. The error code is shown on the LED display. If the controller has stopped to indicate a fault code on the display, the associated time-out delay will vary depending on the nature of the fault.

Troubleshooting requires a systematic approach to diagnose the problems, for example, starting with:

- The system does not work.
- What part of the system? Collector loop.
- What part of the collector loop? Pump.
- What aspect of pump operation? Control.
- Start-up signal? Yes. Contactor operational? No.
- Manually operate contactor--Pump starts!
- Therefore, bad contactor. Replace contactor.

Troubleshooting does not always go that easily. Sometimes the diagnosis requires chasing a fault around checking the components serially. The key to troubleshooting understands the system, having the necessary instruments installed in the system, and using a systematic approach.

These troubleshooting and corrective action guidelines are provided as a sample listing of the problems that may be encountered. The system has been installed and a checkout performed that showed the system to be operating correctly. Tailor the guidelines, through deletions and additions, to each specific site. List the probable causes for each problem in the order of priority in which they should be evaluated to minimize expensive or unnecessary repair work.

Table 5-5: Troubleshooting for Solar Energy System

Item No	Problem	Cause	Corrective Action
1	Your pump delivers little or no water	a. Water level in a low producing well drops too low while pump is operating, causing it to air lock. (Resulting in loss of prime and possibly serious damage to the pump)	a. Lower the pump further into the well, but make sure it is at least five feet from the bottom of the well. Install a control valve in the discharge pipe between the pump and pressure tank. Use the control valve to restrict the flow until the discharge rate does not exceed well recovery rate.
		b. Intake screen is partially plugged.	b. Lime or other matter in the water may build up on screen. Pull pump and clean screen.
		c. Check valve(s) may be stuck.	c. Make sure that the built-in check valve in the pump and any check valves in the discharge line are free to open properly.
		d. Voltage is too low; the motor runs slowly, causing low discharge pressure (head) and high operating current draw.	d. Have a certified electrician verify voltage at the electrical disconnect box (2 wire) or control center (3 wire) while the pump is operating. If the voltage is low, the power company may need to raise it or installation may require larger wire. Discuss this with the power company or a licensed electrician.

Item No	Problem	Cause	Corrective Action
2	Air or milky water discharges from your faucets	Well water may be gaseous	If your well is naturally gaseous and your system has a standard tank, remove the bleeder orifices and plug the tees. If the condition is serious, check with certified well professionals
3	Pump starts too frequently	a. Leak in the pressure tank or plumbing. b. Pressure switch is defective or out of adjustment. c. Check valve is leaking. d. Tank is waterlogged. e. Drop pipe leaking. f. Pressure switch is too far from the tank.	a. Check all connections with soapsuds for air leaks. Fix any leaks you find. Check the plumbing for water leaks. Fix any leaks you find. b. If necessary, replace switch. c. Inspect valves and replace if necessary. d. Captive Air® Tanks: Check the tank for leaks; correct if possible. Recharge tanks to 18 PSI with a 20-40 PSI switch, 28 PSI for a 30-50 PSI switch, 38 PSI for a 40-60 PSI switch, etc. Standard tanks: Check the tank for leaks; correct if possible. Check bleeder orifices and clean bleeders; replace if necessary. e. Raise one length of pipe at a time until the leak is found. When water stands in the pipe there is no leak below this point. f. Move the pressure switch to within one foot of the tank.
4	Fuses blow or overload protector trips when the motor starts	a. Fuses or wires are too small. b. Low or high voltage. c. Cable splices or motor windings grounded, shortened, or open. d. 3-wire only; Cable leads may be improperly connected in pump control box, pressure switch or fused disconnect	a. Replace with correct wire sizes. b. While motor is running, voltage should not exceed plus 5% or minus 5% or rated voltage shown on motor nameplate. Call the electric power company to adjust line voltage if not within these limits. c. Consult certified electrician or service technician. d. Check wiring diagram on pump control box (also see Figure 9 on Page 9) and colour coding of drop cable.

Item No	Problem	Cause	Corrective Action
		switch. e. 3-wire only; there may be a broken wire in the pump control box. f. 3-wire only; Starting or running capacitor in control box may be defective or vented (blown out).	 e. Employ certified electrician examine all connections and wiring in control panel. If necessary, repair them. f. Inspect capacitors. Employ a certified electrician to check capacitors and replace them if necessary. WARNING! Hazardous voltage, can shock, burn or cause death. Capacitors may still carry voltage charges even after being disconnected from wiring. Have them checked by a certified electrician.
5	Motor will not start but does not blow fuses. WARNING! Hazardous voltage. Can shock, burn or cause death. Employ a qualified electricians should work on electrical service.	a. No voltage to motor. b. Cable splices or motor windings may be grounded, shorted or open-circuited. c. Open circuit in pump control box (3-wire only); faulty connections; faulty wires. d. Faulty pressure switch. e. 3-wire only; Cable leads improperly connected in the control center.	a. With a voltmeter check; 1) fuse box to make sure full voltage is available; 2) pressure switch terminals, to make pressure switch is passing voltage correctly; and 3) terminal strips in pump control box or disconnect switch box to make sure voltage is available there. On 1-1/2 through 3 HP: Push red overload reset button(s) on the bottom of control center. b. Consult certified electrician or service electrician. Do not attempt to disassemble pump or motor. c. Examine all connections and wires; examine terminal strips in the control center (3-wire only); repair if necessary. d. Check pressure switch; replace if necessary. e. Check wiring diagram on control center panel (or see Figure 9 on Page 9 of this manual) and color coding of drop cable.
6	Pressure switch fails to shut off pump	a. Voltage is too low; motor will run slowly, causing low discharge pressure (head) and high operating current draw.	a. Have a certified electrician verify voltage at the electrical disconnect box (2-wire) or the pump control box (3-wire) while the pump is operating. If the voltage is low, your power company may require larger wire. Discuss with the power company or a certified electrician. Check voltage with a recording

Item No	Problem	Cause	Corrective Action
			meter if trouble recurs.
		b. Faulty pressure switch.	b. Replace switch.
		c. Drop pipe is leaking.	c. Raise one length at a time until the leak is found. When water stands in the pipe, there is no leak below this point.
		d. Water level in the well may become too low when pump is running	d. Lower pump further into well, make sure it is between five and ten feet from the bottom of the well. Install a valve into the discharge pipe between the pump and the pressure tank. Use the valve to restrict flow until discharge rate does not exceed the well recovery rate. WARNING! To prevent the possibility of dangerous high pressure, install a relief valve in the discharge pipe between the pump and flow restriction valve. The relief valve must be capable of passing full pump flow at 75 PSI
7	Fuses blow or overload protector trips when motor is running	a. Low or high voltage.	a. While the motor is running, voltage should not exceed plus 5% or minus 5% of rated voltage shown on motor nameplate. Call your power company to adjust line voltage if it is not within these limits.
		b. 3-Wire only: High ambient (atmospheric) temperature.	b. Make sure the pump control box is installed out of direct sunlight.
		c. 3-Wire only: Pump control box is wrong horsepower or voltage for installation.	c. Compare horsepower and voltage rating of motor (from motor nameplate) with those of the pump control box (from pump control box nameplate). These numbers must match.
		d. Wire size is too small. Improperly connected in the pump control box.	d. Make sure the wire sizes match specifications in the Table.
		e. Cable splices or motor windings may be grounded, shorted or open-circuited	e. Consult certified electrician or a service technician to determine if this is the cause of the problem or not. Do not attempt to disassemble pump or motor.

5.7 Miscellaneous

5.7.1 Storage Tanks

Drain and flush out water storage tanks annually to remove sediment from the bottom of the tank. Excessive amount of sediment may indicate corrosion problems; test the water and treat it.

5.7.2 Strainer (Filter)

Check and clean strainers (filters) at least twice a year. Finding excessive sediment in the filters for liquid systems could signify corrosion problems. Check and treat the fluid and schedule more frequent cleaning of the strainers.

5.7.3 Valves

Some remotely operated valves require scheduled lubrication. Refer the manufacturer's literature for the maintenance requirements. Cycle these valves periodically to be sure they are working properly.

Check pressure and pressure relief valves periodically but never when the collectors are stagnating. Manually operate the valves using the lift lever. Replace any valves that are stuck (frozen) shut or leaking.

Check automatic air vent valves periodically by: (1) removing cap, (2) depressing valve stem until small amount of fluid is released, and (3) replacing cap, taking care to only tighten two turns to allow proper venting.

Inspect check valves periodically. The inspection should include, if possible, opening the valve (after isolating it from the system) to verify that there has been no erosion or corrosion, that the seat is not damaged, and that the valve operates freely (does not stick), and that the flapper or plunger is not pitted or scaled.

Cycle all manual valves (i-e., opened, closed, and returned to design position) periodically. This prevents freeze-up of the valves. Consult manufacturer's literature for any lubrication requirements.

5.7.4 Fans

Fans, like pumps, can require lubrication on a scheduled basis. Follow the manufacturer's recommendations. In addition, check the fans frequently for noise, loose drive belts (if applicable) and speed, and promptly take corrective action, when needed. Check the operating current draw (amperage) for variation from the as-installed value.

5.7.5 Instrumentation

The primary maintenance of instrumentation is calibration of flow meters, pressure gauges, thermometers, and temperature sensors. Use the manufacturer's literature for the calibration schedules, requirements, and procedures.

5.7.6 Control system

Preventive maintenance for the control system includes repeating the acceptance test control checkout outlined in the installation Manual. The equipment typically required for the check- out includes a multicentre and variable resistance potentiometer.

Annexes

Annex A: Pre-Turn on Checks

1. On the solar panel leads, check the voltage between the two leads. This voltage should read approximately 16-20 volts. Your reading is _____.

2. On the terminal block marked 'BAT+' and 'BAT-' check the voltage between the 2 terminal blocks. This voltage should read between +11.4 volts and +13.4 volts. Your reading is _____. Post-Turn On Checks

3. Verify the LED that is lit on the solar controller Record the colour of the LED that is lit _____.

4. Record the solar voltage being displayed on the controller _____V.

5. Record the array current being display on the controller _____amps and the time of day _____ and weather status (sunny, cloudy, raining) _____.

6. Turn on the load and record the load current being displayed on the controller _____amps.

Annex B: Solar Panel(s)

The current and power output of your solar panel is proportional to sunlight intensity. It is important to install your solar panel so that it is not shaded during daylight hours. The season of the year as well as the azimuth of your panel will affect the output of your solar panel.

Your panel is composed of crystalline cells interconnected to effect the wattage rating of the panel. Further the connection is such that damage to one cell(s) only reduces the output of the panel by the power lost from the cell(s). Thus if only one cell is damaged your panel will still continue to produce power close to the rated output of the panel. The crystalline cells are encapsulated between tempered glass and an EVA potting with PVF back sheet to provide the maximum protection to your cells from environmental factors. The panel is housed in an anodized aluminium frame to provide structural strength and ease of handling.

Annex C: Trouble shooting if the solar pump does not run

Most problems are caused by wrong connections (in a new installation) or failed connections, especially where a wire is not secure and falls out of a terminal. The System ON light will indicate that system is switched on and connected to the controller. It indicates that VOLTAGE is present but (in a solar-direct system) there may not be sufficient power to start the pump. It should attempt to start at intervals of 120 seconds.

Pump attempts to start every 120 seconds but does not run. The controller makes a slight noise as it tries to start the pump. The pump will start to turn or just vibrate a little.

1. There may be insufficient power reaching the controller. A solar-direct (non-battery) system should start if there is enough sun to cast a slight shadow. A battery system should start if the supply voltage is greater than 22 V (24 V system) or 44 V (48 V system).

2. If the pump was recently connected (or reconnected) to the controller, it may be running in reverse direction due to wiring error.

3. If the motor shaft only vibrates and will not turn, it may be getting power on only two of the three motor wires. This will happen if there is a broken connection or if you accidentally exchanged one of the power wires with the ground wire.

4. The pump or pipe may be packed with mud, clay, sand or debris.

5. Was the pump stored in water for more than three months? This might cause the pump to seize. Pumps will not be damaged, but might have to be pulled to free them again. Let stored pumps run every 2 – 3 months in order to avoid seizure.

6. Helical rotor models: The rubber stator may be expanded from heat, due to sun exposure or pumping water that is warmer than 72°F (22°C). This may stop the pump temporarily, but will not cause damage.

7. Helical rotor models: The pump may have run dry. Remove the pump stator (outer body) from the motor, to reveal the rotor. If there is some rubber stuck to the rotor, the pump end must be replaced. (for surface pumps)

8. Helical rotor models: The check valve on the pump may be faulty or stuck, allowing downward leakage when the pump is off. This can prevent the pump from starting.

9. Is the pump installed in a negative suction head application? This is an abnormal situation and will pull the rotor out of the pump stator causing possible damage inside the motor as this is an abnormal working direction for all pumps. Negative suction head means that you do not need a pump at all since the delivery point is below the water source level in the source (wells, ponds etc.).

Annex D: Inspecting the Solar Energy System

a) Inspect the solar array

1. Is it facing the sun?

2. Is there a partial shadow on the array? If only 10 % of the array is shadowed, it can stop the pump!

b) Inspect all wires and connections

1. Look carefully for improper wiring (especially in a new installation).

2. Make a visual inspection of the condition of the wires and connections. Wires are often chewed by animals if they are not enclosed in conduit (pipe).

3. Pull wires with your hands to check for failed connections.

c) Inspect the controller and junction box

1. Remove the screws from the bottom plate of the controller. Move the plate downward (or the controller upward) to reveal the terminal block where the wires connect.

2. First, check for a burnt smell. This will indicate a failure of the electronics. Look for burnt wires, bits of black debris, and any other signs of lightning damage.

3. Open the junction box. Is the Power IN switch turned ON? Pull on the wires to see if any of them have come loose.

4. Inspect the grounding wires and connections! Most controller failures are caused by an induced surge from nearby lightning where the system is NOT effectively grounded. Ground connections must be properly made and free of corrosion.

Check the low-water probe system

If the controller indicates “SOURCE LOW” when the pump is in the water, inspect the low-water probe system. The probe is mounted on, or near the pump. If inspection is not feasible, you can bypass the probe or test it electrically.

Annex E: Electrical testing of the Solar Energy System

1. If the probe is NOT being used, there must be a wire between terminals 1 and 2.

2. The probe is a cylindrical plastic device mounted on or near the pump. It contains a small float on a vertical shaft. The float must be able to move up to indicate that it is submerged, and down to indicate that it is dry.

3. The probe must be positioned vertically (within about 10°).

4. The probe or a probe wire may be broken. Inspect the wires for damage.

5. Does the pump run when the probe is OUT of the water? This can happen if the float in the probe is stuck. In surface water, this can happen from algae, a snail, or other debris.

6. If the pump was purchased before and stored for long, it may have a wet-electrode probe. In case of trouble, it can be replaced with a new (mechanical float) probe, with no changes to wiring or controller.

Check the full-tank float switch:

If the controller indicates “TANK FULL” when the storage tank is not full, inspect the float switch system. If your system has a float switch, it will be mounted in the tank. If inspection is not feasible, you can bypass the switch or test it electrically.

1. If a float switch is NOT being used, there must be a wire between terminals 4 and 5.

2. Inspect the float switch. Is it stuck in the UP position?

3. There are two types of float switch, normally-open and normally-closed. Check to see that the wiring is correct for the type that is used.

Force a quick start:

If you restore a connection or bypass the probe or float switch, there is no need to wait for the normal time delay. Switch the on/off switch (or the power source) off then on again. The pump should start immediately if sufficient power is present.

Annex F: If the pump runs but flow is less than normal

1. Is the solar array receiving shadow-free light? (It only takes a small shadow to stop it.) Is it oriented properly, and tilted at the proper angle?

2. Be sure you have the right pump for the total lift that is required, out of the well + up the hill. In the case of a pressurizing system, the pressure head is equivalent to additional lift (1 PSI = 2.31 feet, 1 bar = 10 m).

3. Be sure all wire and pipe runs are sized adequately for the distance. Refer to wire sizing in the pump sizing table,

4. Inspect and test the solar array circuit and the controller output, as above. Write down your measurements.

5. There may be a leak in the pipe from the pump. Open a pipe connection and observe the water level. Look again later to see if it has leaked down. There should be little or no leakage over a period of hours.

6. Measure the pump current and compare it with the table in the previous reading.

7. There is a “max. RPM” adjustment in the controller. It may have been set to reduce the flow as low as 50 %.

Has the flow decreased over time?

1. Is the AC motor current lower than normal? The pump end (pumping mechanism) may be worn from too many abrasive particles (sand or clay) in the water.

2. Is the AC motor current higher than normal? Doesn’t start easily in low light? This is likely to be related to dirt in the pump and/or pipe.

3. Look in the water tank or pipes to see if sediment has been accumulating.

4. Run the pump in a bucket to observe.

5. Remove the pipe from the pump outlet (check valve) and see if sand or silt is blocking the flow.

6. If the check valve itself is clogged with dirt,

7. To help prevent dirt problems, try to Coping with Dirty Water Conditions.

8. After years of use, it may be necessary to replace the pump end. Call your pumps supplier for advice

Annex G: GENERAL SOLAR PV Inspection and Routine Maintenance Guide

If the pump runs but flow is less than normal

A grid connected General Solar PV system is a potentially dangerous, high voltage electrical generator and should be inspected at least every six months to ensure that all system components are working correctly.

Appropriate maintenance should occur at least before the onset of both summer and winter.

CAUTION

General Solar PV photovoltaic modules produce electrical energy when exposed to the sun, including under cloud, or other light sources. The power of an individual module is not considered dangerous but when connected in series and / or parallel the danger of an electric shock will increase.

The DC voltage produced by General Solar PV modules can reach up to 1000V during the day even if the inverter is not switched on. The module surface can become slippery when wet and operatives must follow appropriate safe working practices when accessing General Solar PV systems.

GENERAL ADVICE

- Ensure that appropriate safety signs are in place at each access point to the installation.
- When working on a roof, ensure you are properly tethered and that your safety equipment is in safe operating condition.
- Avoid walking on photovoltaic modules and utilize access routes where provided.
- Do not cut or fold the photovoltaic modules for any reason.
- Do not apply screws, nails etc and avoid letting pointed or heavy objects fall onto any part of the module. Such action could cause shock, generate flame, and invalidate any warranty.
- Do not place any device on top of the photovoltaic modules.

INSPECTION & MAINTENANCE GUIDANCE

The following procedures should be completed during each operation and maintenance visit:

- Visually check that each laminate is bonded perfectly to the waterproof membrane. If any areas of the laminate are NOT perfectly bonded, mark the product with a permanent marker or crayon. If this de-bonding gets worse over subsequent maintenance visits, carry out the following repair advice:

  Re-establish the adhesion by a combination of hot air and pressure from a Teflon coated roller or by applying Solar fill glue and pressing the two elements together until they adhere.

- Check the top surface of each laminate for any scratches or surface damage. Patch any surface damage in accordance with module manufacturer repair guidelines without delay. If the PTFE top surface becomes damaged and is not repaired quickly, system performance can be degraded and the laminate could fail.

- Visually inspect cables and cable ducting, verifying that adequate strain relief is provided and the connections are tight, secure and free from corrosion. Ponding water on laminate surface should be avoided, laminates should not be subjected to ponding water and cables should be housed off the membrane surface in an appropriate free-draining cable tray. The most appropriate time to carry out this inspection is just before and/or just after the winter (or rainy) season.

- Cable trays should be secured to the roof membrane with the Security of attachment should be visually checked.

- Clean laminates which are particularly dirty or have localized shading (bird droppings, leaves, etc.).

- During the pre-summer visit, check the extent of dirt on the module surface and perform cleaning if this is warranted.

- Verify that all laminates are located in areas that have no shading, and remove temporary objects that may be shading the array and reducing system performance. For example, prune trees that may be shading the array during the summer months.

- Ensure that the drainage system is not blocked and that there is no potential for water pooling on the laminates.

SYSTEM COMMISSIONING & TROUBLESHOOTING FOR ELECTRICIANS AND MAINTENANCE STAFF

The following tests should only be performed by trained and qualified personnel. The best weather conditions that will provide the most accurate system tests are cloudless days with strong sun conditions.

- Before starting PV system maintenance, check that metal parts (array frames, junction box enclosures, DC disconnect switch enclosures, inverter enclosures) are earthed properly.

- When working on the PV Laminates, always wear electrical gloves and shoes and use only insulated tools rated for the maximum rated system voltage (i.e. 600 VDC), disconnect all energy source (i.e. battery and/or utility) and short-circuit the output of the PV Laminates.

- If more than one ground rod is being used, verify that all ground rods are bonded together with appropriately sized conductors.

- Measure and record the open circuit voltage of each series string, verifying that all strings that are feeding the same inverter have the same polarity and a similar open circuit voltage (within ± 5V of each other). If the variation in string voltages is greater than 5V, check the individual connections to that string of laminates.

- Measure and record the operating current of each series string and verify that all strings with the same number of laminates have a similar operating current (within ±

1A of each other). A variation in operating current can indicate areas of the array which are shaded or are particularly dirty and should be investigated further.

- Check the alarm status of each inverter and also the historical alarm log if this is available (refer to inverter manufacturer's manual). Any alarm which indicates either a low resistance or an earth leakage fault should be investigated as soon as weather conditions permit, by suitably qualified personnel.

- Record DC and AC power (at the input and output of the inverter) and determine inverter operating efficiency.

- Perform and record insulation resistance (Riso) on the input to each inverter.

- Checks that system fuses and DC disconnect switches are operational.

- Check for loose wires or connections at all solar system array controller (voltage regulator), Combiner Boxes, and/or other Junction Boxes within the system.

- Perform maintenance on the inverter(s) as stipulated by the manufacturer (clean filters, etc.).

- Confirm that no new loads have been added to the system and that loads are operating for the specified number of hours per day.

CLEANING PV LAMINATES

Generally, a good rain is sufficient to clean the PV Laminates. However, in dusty arid locations the PV Laminates can be cleaned with water or mild soap and water in accordance with the following procedure. However avoid cleaning the panels in the middle of the day and do not use abrasive soaps or solvents.

GENERAL RECOMMENDATIONS

- Wear rubber soled boots and cut resistant gloves when cleaning laminates.

- Survey the roof for any loose wires, damaged modules and tough stains that will require special attention.

- While surveying, remove all large debris from the roof surface.

- Use a leaf blower to remove all small sized debris from the roof surface.

- Use a garden hose to get the entire PV laminate wet, making sure not to spray water on electrical wires.

WHEN TO CLEAN

The amount of electricity generated by a solar cell is proportional to the amount of light falling on it. A shaded cell will produce less energy. The non-stick PTFE top surface of General Solar PV modules promotes automatic self-cleaning. It is normally NOT necessary to perform an all-encompassing cleaning of dirt from the solar array, provided that the array is installed on more than a 5% slope.

Cleaning should be performed on any modules that are excessively affected by a collection of bird droppings, dirt, or miscellaneous debris, such as fallen leaves. This

cleaning should be performed at each maintenance visit. The monetary value of cleaning dirt and debris from the array is a trade-off between the cost of the cleaning, increased energy production as a result of the cleaning, and the inevitable re-soiling of the laminates over time once they have been cleaned.

To help determine the performance benefit of cleaning, perform the following steps to measure the short circuit current of individual laminates before and after cleaning: Measure and record the operating voltage of each series string and verify that all strings feeding the same inverter have a similar operating voltage (within ± 5V of each other). Any difference greater than 5V between strings requires investigation.

- Isolate a single string, making sure all the DC isolation switches are open (OFF) and all the string fuses have been removed.
- Disconnect the laminates that will be used for the test by opening connections via an MC4 disconnect tool.
- Verify that the current sunlight is effectively constant (clear sky, strong sunshine, no clouds)
- Connect a DC millimetre across the terminals (10A or greater) to measure and record short circuit current.
- Clean the laminate as described in the Cleaning Procedure below.
- Measure and record the current and verify the percentage difference between the two readings. This percentage difference is the potential gain that will be derived from cleaning the product.

CLEANING PROCEDURE

Clothing - Anti-slip rubber shoes and gloves.

Tools - Soft brush, dry cotton mop or clean broom.

- Low pressure water or portable pressurized water tank.
- Biodegradable, non-abrasive mild detergent.
- Clean water source.

- Check earth connection of PV modules and inverter.
- Examine the roof for damaged modules or persistent staining.
- Remove all waste matter lying on the modules.
- Wet the area avoiding the electrical cables.
- Using soft brush remove excess dirt.
- Pressurized power washers should **NOT** be used directly on the laminates. If these devices are being used to clean the roof around a solar array, ensure that the nozzle of the power washer remains at least two feet away from the surface of the laminates at all times while cleaning.

- When spraying a module, **do NOT** spray water directly on the electrical connections or at the leading edge of the PV laminate.
- Use caution when cleaning PV modules, as the combination of water and electricity may present a shock hazard.
- Use a soft brush to scrub stubborn stains, be careful not to scratch the surface.
- Rinse with water to remove all traces of detergent.
- Dry any puddles left on the roof post cleaning.

Annex H: Typical failures of V-belts and their reasons

No	Type of failure	Probable reasons
1	Belt rapture after short period of operation	▪ belt tearing during mounting on pulley; ▪ drive blockage with respect to failure of driven machine or foreign body entrapped inside the drive; ▪ poorly calculated drive with too small number of belts (poorly calculated coefficient of conditions of operation kT);
2	One-side usage of belt at its side wall	▪ too big not-parallelism of belt pulleys axis;
3	Earlier usage of side surfaces at whole length of belts	▪ too big torque (mainly for drives with big start-up torque during driving machine start- -up and big resistance torque during start-up of driven machine is necessary to use equipment ensuring soft start); ▪ improper angle or excessive usage of groove of pulley; ▪ too small belt tension; • too often short-term overloads of gearing with respect to failure of driving machine; ▪ too small number of belts; ▪ lack of parallelism of belt pulleys setting; ▪ minimal pulley diameter is exceeded; ▪ surface of grooves possess to big roughness
4	Local usage of side surfaces	▪ too small belt tension; ▪ blockage of driven machine pulley with respect to bearing failure
5	Grooves at side surface at whole belt length	▪ belt friction because with contact with part of a machine; ▪ belt works in used-up groove of pulley; • improper groove cross-section

No	Type of failure	Probable reasons
6	Transversal belt breakage at the bottom side.	▪ usage of external tension roller instead of internal; ▪ too small diameter of tension roller; ▪ excessive or too small temperature of operation; ▪ too big slippage; ▪ chemical influences; ▪ excessive belt tension;
7	Indurations and ruptures of a wrap.	▪ strong influence of dust; ▪ too big ambient temperature; ▪ influence of chemicals
8	Detachment of cloth wrap and symptoms of rubber bulging.	▪ reason of long-term influence of oil, grease or other chemicals at a belt
9	Strong vibration.	▪ base of axle bigger then is recommended; ▪ big shock load; ▪ too small belt tension; ▪ non balanced grooved pulleys; ▪ overloaded drive; ▪ angle of groove is not correct
10	Twisting of belt	▪ lack of coaxiality in pulleys setting; ▪ not correct belt or groove profile; ▪ excessive vibration; ▪ too small belt tension; ▪ penetration of foreign material into grooves; ▪ overloaded drive;
11	Falling of belts from pulleys after short period of operation	▪ too small belt tension; ▪ too small frequency of control and adjust- ment of belt tension;
12	Too loud operation of gearing	▪ belt pulleys are not set coaxial; ▪ too small belt tension; ▪ overloaded drive; ▪ grooved pulleys not balanced;

No	Type of failure	Probable reasons
13	Uneven belts stretching.	▪ faulty belts grooves; ▪ used belts do not create a set of belts; ▪ a few belts from a belt unit were replaced by new ones; ▪ unit of belts composed of from belts of different producers;
14	Excessive heating of bearings.	▪ bearings not lubricated; ▪ grooved pulleys not balanced; ▪ too big tension
15	. Lowering of speed of driven pulley;	▪ .check relationship between diameters of pulleys and their speeds; ▪ too small tension;
16	Different tension of single belts working in belt unit.	▪ belts do not create a set of belts or do not possess marking L=L; ▪ different pitch diameters of particular grooves in belt pulley; ▪ usage of belts of different quality in one set as well as belts; ▪ coming from different producers; ▪ a few belts from a belt unit were replaced by new ones.

Annex - I: Solar System Maintenance Schedule

Maintenance Task	Daily	Weekly	Monthly	3 Months
Visual Inspection of system wiring, Lights and vaccine freezer		√		
Solar Panel Maintenance				√
Battery Inspection		√		
Battery Cleaning			√	
Wiring Inspection		√		
Inverter/Battery Charger		√		
Charge Controller		√		
Battery "top-up"			√	

Annex J: Panel Maintenance Log Sheet (every 3 months)

Date	Name of Maintenance Technician	PV Module Clean		Array Frame			Array Cabling	Array Output voltage
		Yes	No	Good	Fair	Bad		

Annex K: Weekly Battery Inspection Log Sheet for "Deep Cycle Flooded" Lead acid Battery

Date	Battery Number	Specific Gravity	Terminals/Connection Tight		Voltage	Water Level			Action Taken
			Yes	No		Good	Fair	Low	

Annex L: Weekly Battery Inspection Log Sheet for AGM and GEL Batteries

Date	Battery Number	Terminals/Connection Tight		Voltage	Action Taken
		Yes	No		

Solar and Wind Energy

Pastoral Area Water Supply

(Parts E, F, G, H)

Solar and Wind Energy, Community and Financial Management of the Pastoral Areas

PART – F: WINDPOWERED PUMPING SYSTEM

Document 10

PART – F: WINDPOWERED PUMPING SYSTEM

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Function of Wind Turbine Components

Rotor **T**he rotor captures the kinetic energy of the wind and converts it into

	rotary motion to drive the generator.
Control and Monitoring	The control and monitoring system consists of a main controller in the turbine base, a remote controller in the nacelle, and another in the hub. The base unit contains a user interface and display. Control sensors include wind measurement instruments, rotor speed control, and power/grid monitoring transducers; sensors specific to monitoring component condition (e.g., PT100s for the generator) are included in that component category.
Drive Train	The drive train consists of a main shaft supported by two main bearings, coupled to the gearbox with a hydraulic shrink coupling. A composite tube with flexure connections is used to couple the gearbox to the generator.
Electrical Power and Grid	The turbine switchgear consists of a main breaker / disconnect, a line contactor for the generator power, and smaller contactors and circuit breakers for ancillary systems and power factor correction capacitors. A soft-starter is included for connecting to the grid for constant-speed machines
Gearbox	The gearbox is a combination planetary/helical unit with an integral lubrication system and fluid cooler system. The gearbox is suspended from the bedplate with elastomeric bushings
Generator	The generator is single-speed, induction type. The variable-speed machine includes a wound rotor and slip-rings. Cooling is provided by an integral forced-air system
Brake	The brake is a calliper-type located on the gearbox high-speed shaft. A dedicated hydraulic system provides pressure for the callipers. The brake is used only for parking, as the primary rotor brake is the blade pitch system
Yaw System	The yaw bearing is a sliding-bearing type with spring-applied calipers for stabilization. The surfaces are periodically lubricated with grease. The yaw drives are electric-motor driven with a multiple-reduction gearbox. The number and size of the yaw drives increase with turbine size
Tail	The tail keeps the turbine facing into the wind. Tower Because wind speeds increase with height, the turbine is mounted on a tower. In general, the higher the tower, the more power the wind system can produce.
Tower	The tower also raises the turbine above the air turbulence that can exist close to the ground because of obstructions such as hills, buildings, and trees. A general rule of thumb is to install a wind turbine on a tower with the bottom of the rotor blades at least 9 meters above any obstacle that is within 90 meters of the tower.

6. WINDPOWERED PUMPING SYSTEM

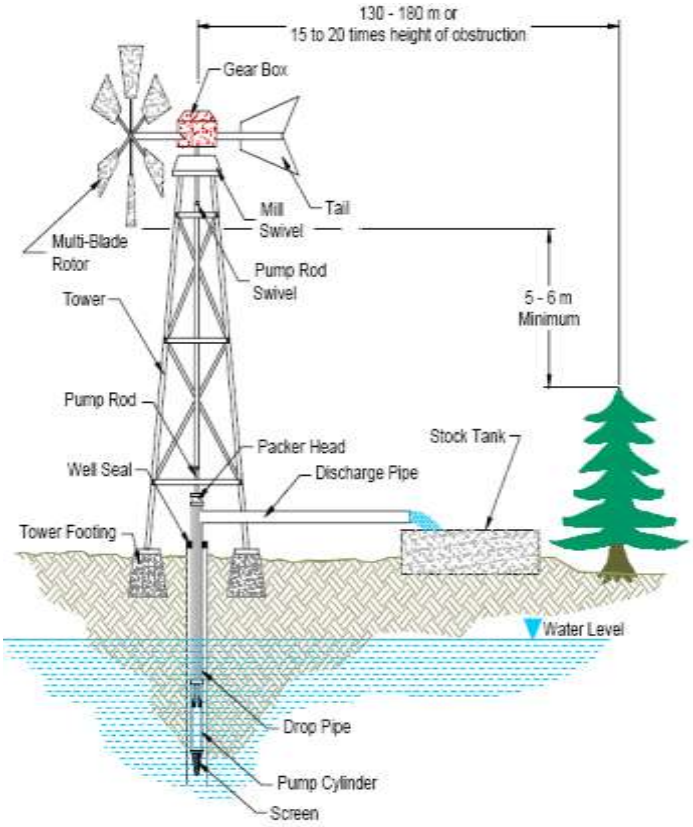
6.1 General

The wind technologies consist of either conventional mechanical wind pumping systems using a small wind turbine installed directly over the well and powering a positive displacement pump, or wind- electric pumping options using a wind turbine to generate AC power to run a submersible centrifugal pump.

Wind pumping systems are generally a viable option in areas with average wind speeds above 3 to 4 m/s, with mechanical systems preferred at lower wind speeds.

Figure 6-1: Typical Wind Energy System

Windmills can provide the energy to move a pump. The most common models have a rotor fixed to a horizontal axis that is mounted on a steel tower. The tower of the windmill is usually 9–15 m high. Wind drives the rotor and this movement is transmitted to drive a pump (usually a piston type), either directly or via a gear box. A vane keeps the rotor facing the wind during normal wind speeds, but there is also a mechanism to position the rotor parallel to the wind to avoid damage to it from excessive wind speeds. Some windmills are fixed facing the wind, others are manually oriented, and some have a braking system.



Wind power machines are classified as mechanical (without electric generators) and electrical. Mechanical are the ones focused on here, as they are mostly used in rural and remote areas for water pumping. Electrical windmills connect to a power grid and produce energy converted to electricity for heating, transportation, and other mechanized power.

6.2 What is Wind Power?

Wind power captures the natural wind in our atmosphere and converts it into mechanical energy then electricity. People started using wind power centuries ago with windmills, which pumped water, ground grain, and did other work. Today's wind turbine is a highly evolved version of a windmill. Modern wind turbines harness wind's kinetic energy and convert it into electricity. Most wind turbines have three blades and sit atop a steel tubular tower, and they range in size from 24m tall turbines that can power a single home to

utility-scale turbines that are over 79m tall and power hundreds of homes. Wind is a type of renewable energy, and there are three major types of wind power.

The major types of wind power are:

- Utility-scale wind: wind turbines larger than 100 kilowatts are developed with electricity delivered to the power grid and distributed to the end user by electric utilities or power system operators;
- Distributed or "small" wind: which uses turbines of 100 kilowatts or smaller to directly power a home, farm or small business as it primary use;
- Offshore wind, which are wind turbines erected in bodies of water around the world.

6.3 Why Wind Power?

- Power demand is growing with increased populations,
- Wind Power can bring energy to remote areas outside the "electrical grid." It is cheaper in to start a wind power system than to bring in power lines or other types of fuel which are hard to transport,
- Wind is a renewable resource where as conventional methods such as coal, natural gas, and oil are limited (they have finite lifetimes),
- Wind Power does not produce the greenhouse (carbon) emissions of conventional energy methods and thus will reduce these if used in their place,
- The price of installation, implementation, and maintenance has dramatically dropped in the past two decades making wind a more viable economic option even in developing countries. As technology advances, costs will continue to drop,
- Wind power can be converted to other forms of energy (Wind Energy Conversion Systems - WECS):
    - Electric - used for heating, light, transport, and running mechanical machines
    - Mechanical - mostly converted to hydraulic power to pump a supply of water for irrigation and every day use from deep water levels
- Utilization of wind power for heating and lighting will lesson local environmental degradation as it replaces mass collection of fuel wood (which causes deforestation and erosion/ watershed damage) as well as the usage of kerosene and animal dung for these purposes.
- Regular diurnal wind patterns in an area suggest that wind power will be an optimum choice for an energy system Reliability of WECS is improving with increased technology.

6.4 Identification of Components

The main components of the wind pump are the following, look at Figure 6.1 above:

- Wind
- Rotor
- Tower
- Transmission assembly
- Pump rods

- Riser and stuffing box
- Outlet
- Base plate
- Borehole casing

6.5 Operation and Maintenance

Operation of most of these non-conventional systems is relatively simple, although most require additional labor. Most of the pumps require the use of anti-corrosive paints to protect the exposed metal parts, and frequent oiling (twice a month) of the parts of the pump where friction between different parts can be expected. However, it is important to avoid the use of heavy-metal-based (e.g., lead paints) and to avoid contaminating the insides of the pumps with hydrocarbon residues, especially if the water is to be used for human consumption. Such contamination can lead to chronic public health problems.

Operation is often automatic. Some windmills require manual release of the furling mechanism after excessive wind. When no pumping is needed, the windmill may be temporarily furled out of the wind by hand. Windmill and pump should be checked regularly and any abnormality corrected.

Every month, the windmill and pump must be checked visually.

The bolts on the pumping rods tend to come loose, and loose nuts and bolts should be tightened and moving parts greased, as necessary.

Paintwork should be maintained annually, and the lubrication oil changed in the gear box (if one is used).

Poor maintenance will lead to the bearings wearing out rapidly and the wind will then damage the rotor and other pump parts.

6.5.1 Control Unit(s)

When the wind is strong enough by selecting the control mode, the controller would only output signals to the proportional speed-regulating valve and the pumping unit should be made run according to the given flush times by adjusting the over-current of the valve port.

When the energy provided by wind turbine is not enough, the variable frequency controller would output the control signals and the system's requirements could be supplied by controlling the speed of the Hydraulic pump and adjusting the over-current of the Hydraulic pump. Use the controller to give orders to the Hydraulic drive system to make the switch of the up-down stroke and to recover the gravitational potential energy loaded at the down stroke by using the accumulator to make it reusable at the up stroke.

System structure & operating principle:

When surrounding air speed greater than rated wind speed, the selectivity part would output control variable to proportional speed-regulating valve and enable the fluctuation of over-current quantity (Q) to follow with controlled variable. At this moment, the control voltage of frequency converter is zero, the asynchronous machine do not drive the hydraulic pump to run.

When surrounding air speed less than rated wind speed, the over-current quantity of proportional speed-regulating valve would be maintained at Q_{max}. The selectivity part would output control variable to frequency converter and enable the fluctuation of hydraulic pump's flow to follow with controlled quantity. The process will complement required oil for system, and thus, it will make the pumping unit would be made run according to the given flush times.

6.5.2 Safety Procedures

Safety is the most important issue in wind pump installation and maintenance. Life-or-death situations can arise when working with wind machines, so proper follow-up of installation and maintenance is necessary. Proper installation requires thoughtful planning and understanding installation procedures, from foundation work to anchoring to wiring (in case of wind-electric turbines), and on to the installation of subsystems.

Some basic safety precautions to prevent installation and maintenance accidents follow.

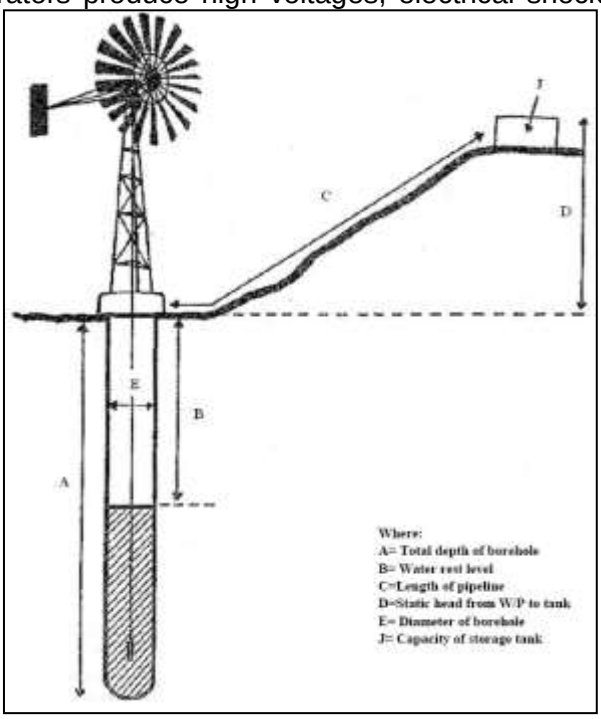
Box 2: Safety Procedures for Wind Pump

1. Before climbing towers, manually furl (tie-up) the wind pump. The wind pump furling mechanism should be checked periodically. The furling mechanism tension spring should be adjusted to ensure that furling occurs at the correct wind speed. Adjustment of the furling spring tension should begin with a lighter setting (after installation of the wind pump), so it furls at lower wind speeds. Increasing the tension of the spring can be done once the wind pump runs. When climbing the wind pump keep your feet clear of the moving pump rods, and check you are not coming up directly under the rotor,
2. Always work on the wind pump with at least two people, never work on a wind pump alone,
3. Keep your fingers well clear of any moving parts,
4. If possible do not stand or work underneath the wind pump, when someone is working on it, unless you are wearing a hard hat/helmet,
5. It is good practice to wear hard hat/helmet at all times, even if you are just climbing the wind pump to check its operation. It is quite easy to get distracted and this could result in the crank striking your head, as it rotates,
6. The towers have steps built into one of the tripod legs, please use them,
7. The tower is designed with sufficient clearance between it and the tower legs, to allow you a safe clearance, should the rotor change direction, while you are up on the wind pump,
8. Even if you are experienced with working up on the wind pump, it is also still a good idea to use a simple quick release harness, to attach yourself to the tower. This also allows you to use both hands when necessary,
9. Never allow children to play on or near the wind pump,
10. Experienced people actually sit on top of the transmission while checking or servicing it. No matter how experienced you get, never do this without securing the rotor first,
11. While servicing your machine it is easy to leave grease on the tower. Please make sure it is wiped off before you leave, as it could cause someone to slip.

Electrical safety precautions must be taken to avoid electrical shocks when working on electric wind pumps. Because wind generators produce high voltages, electrical shocks can be fatal.

Precautions must be taken when servicing or installing storage batteries. Ventilate the battery storage area to prevent hydrogen accumulation. In addition, wear goggles to protect the eyes whenever working around batteries. Storage batteries must also be protected from discharging.

Fencing the wind pump is important to prevent children from climbing on the tower, or preventing horses and cattle from scratching their backs on the tower edges. Guy cables should be kept away from pathways as much as possible, to prevent vandalism and loosening of tension through normal vibrations.



6.5.3 How to Tie and Secure the Rotor

A typical small wind generator has rotor that is directly coupled to the generator which produces electricity either at 120/240 volt alternating current for direct domestic use or at 12/24 volt direct current for battery charging. Larger machines generate 3 phase electricity. There is often a tail vane which keeps the rotor orientated into the wind. Some wind- machines have a tail vane which is designed for automatic furling (turning the machine out of the wind) at high wind speeds to prevent damage. Larger machines have pitched controlled blades (the angle at which the blades meet the wind is controlled) which achieve the same function. The tower is of low solidity to prevent wind interference and is often guyed to give support to the tower.

How to Furl and Secure the Wind Pump Rotor:

a) Choose an undamaged piece of rope at least 2 cm thick, and long enough to pass a double strand round both anchor points on the rotor

b) Secure the middle of the piece of rope securely underneath one of the tower cross beams just opposite the rotor ring

c) Take one end and loop it round where the blade spar crosses the rotor ring, and choose one where the blade is together with a rotor support spar. This will reduce the chance of damage to the rotor or blade spar if the wind changes direction very strongly during maintenance.

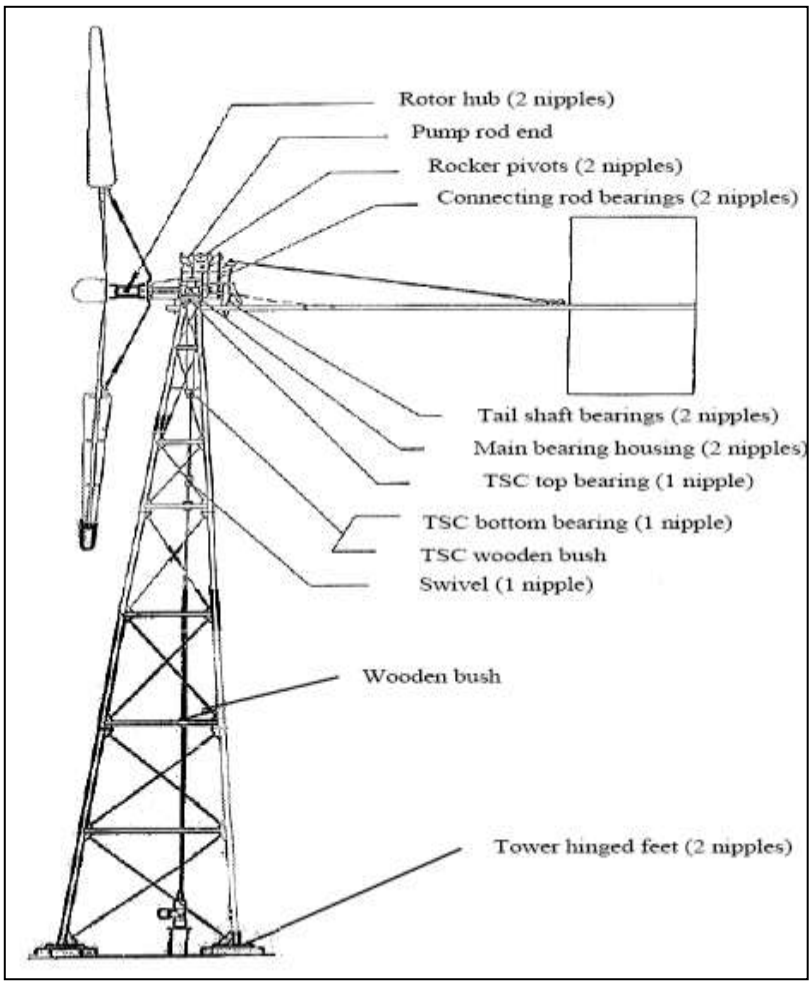
d) Having secured the rotor in this one place, get the assistant to turn the rotor until the rope is tight, and then take the other end of the rope and lash it in the opposite direction to another blade and support bar.

e) Make sure the knots are tight

f) Never leave the wind pump tied up after leaving. A strong wind could result in the rotor being bent.

g) Never try to furl the wind pump while up the tower; this can be dangerous

h) Never leave the rope hanging from the furling chain, after the



i) maintenance has been carried out, as it could get entangled,

j) damaging the rotor, or enable unauthorized people to tamper with the machine

k) Make sure at least two people (the operator and assistant) can demonstrate how to do this satisfactorily.

Figure 6-2: Locations of windmill lubrication

6.5.4 Greasing

This is the main routine maintenance activity that should be carried out on wind pumps. Greasing prevents wear on the moving parts and helps to ensure that the wind pump runs for a long time without requiring major repairs. See Figure 6.2 for the locations of lubrication.

a) Greasing must be done using a GREASE GUN.

b) Greasing should be done EVERY 6 MONTHS.

c) Each greasing session will use approximately 1 x ½ kg tin of grease.

d) Apply 2-3 strokes of the grease gun on each grease point.

e) The points that should be greased are shown on Diagram shown in Figure 6.2; they are marked on the machine in “red”.

f) Make sure at least two people (the operator and assistant) can locate the grease points and demonstrate how to do the greasing satisfactorily.

6.6 Equipment Functional Checks

All sensors should be inspected and their functionality tested before being installed and when applicable, as part of the scheduled operation and maintenance requirements.

Generally, tower lowering or climbing should not be necessary to perform these tasks. Unless the data validation process has detected potential problems, the scheduled anemometer and wind vane checks should be visual with binoculars, with attention directed toward physical damage. Damaged or suspect equipment should be replaced or repaired. The results of all functional checks must be documented. General sensor quality control procedures are described below:

- **Anemometers:** Ensure that the sensors are rotating freely and that the mounting hardware and sensors are intact and oriented correctly. Ensure that the sensor inputs to the data logger are reasonable.

- **Wind Vanes:** Ensure that the sensors are rotating freely and that the mounting hardware and sensors are intact and oriented correctly. Ensure that the sensors inputs to the data logger are reasonable. If there are discrepancies, check the dead band position.

- **Temperature Sensor:** Compare the temperature sensor readings to a calibrated thermometer at the same location annually. The test duration should be at least one-half hour with readings taken at 5-minute intervals. Deviations between sensors should not exceed 1°C.

- **Support Tower:** For tilt-up towers, ensure that the tower is vertical. Make any necessary adjustments to guy wire tensions.

6.7 Spare Parts Inventory

Projected operation and maintenance functions must anticipate potential equipment malfunction and breakage. To minimize downtime, an adequate spare parts inventory must be maintained and included with all site visits. The basic inventory should consist of all items necessary to outfit one monitoring station. Additions to specific inventory items may be appropriate.

You should consider the following points when determining your specific inventory needs:

- **Size of the Monitoring Network:** As the size of your monitoring network increases, a corresponding increase in your spare parts inventory may be warranted. As a guide, networks consisting of six or more monitoring stations should have a parts inventory sufficient to outfit two stations. For networks of this size it is also advisable to have a spare data logger on hand.

- **Environmental Conditions:** Weather-related events, such as severe thunderstorms and icing, pose a significant risk to a site's operation. Networks in geographical areas prone to either type of event should be equipped appropriately. Mechanical failures from ice loading or extreme wind gusts, as well as electrical failures from nearby or direct lightning discharges, can occur. Recommended additions to specific inventory items include spare anemometers, wind vanes, and sensor mounting booms. The need to maintain an additional data logger in your inventory, at significant expense, can be reduced by selecting high reliability models that include transient protection and internal shielding.

- **Equipment Availability:** The availability of inventory items from each supplier should be considered, and their in-stock inventory determined in advance. Items that require an extended lead time for delivery should be identified and inventory numbers adjusted accordingly. The turn-around time for critical items, such as data loggers and sensors, is particularly important.

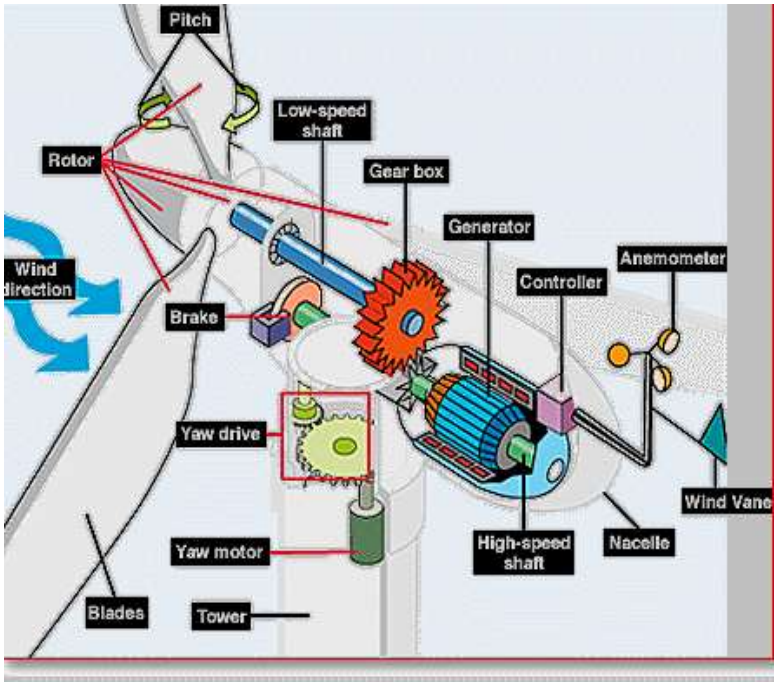
- **Operation and Maintenance History:** The servicing needs of a site should be closely monitored. If warranted, specific item inventories should be adjusted based on experience at each site to maintain a high level of service preparedness.

6.8 Replacement Parts of the Turbine

This category includes all replacement parts for the turbines, exclusive of consumables. The parts that are considered candidates for replacement, including mechanical, electrical, and hydraulic components, are those that wear or deteriorate during normal use.

Mechanical parts that experience any form of friction, contact, or flexure (e.g., bearings, seals, gears, diaphragms, brake and yaw pads) are all candidates, although the failure rate can vary dramatically depending on the design life and duty cycle. Fatigue of mechanical and structural components is explicitly omitted from the model, which assumes that the load-carrying components are designed with adequate design life for the imposed loads and duty cycle. For example, gearboxes are included in mechanical wear items, but the main shaft and bedplate are excluded. By the same reasoning, blades are assumed to structurally survive for the design life of the turbine, although the model assumes that minor blade repairs or refinishing to compensate for damage or wear will be required.

Hydraulic parts: include pumps, valves and hoses, cylinders, and callipers. There are two distinct failure modes for these components, which have different failure distributions. In general, hoses will deteriorate over time regardless of use, and thus will have a calendar replacement schedule. The other components will wear based on use, and thus will have a replacement distribution based on operating hours.



Electrical components: such as contactors and circuit breakers that include contacts and moving parts are candidates for wear; main power cables are assumed to last for the life of the machine. Solid-state components such as control boards, power converter regulator boards, and soft-start trigger boards are included as they exhibit thermal deterioration over time. Motors and generators are included as the bearings wear mechanically and the windings fatigue thermally and mechanically with use.

The parts are segregated into the categories shown in Table 6-1. For each category, the major cost items are included and minor cost items are placed into a miscellaneous category.

Table 6-1: Categorized Components of Turbine Replacement

No.	Components	Parts
1	Rotor	Blades, pitch bearings, pitch actuators
2	Drive train	Main bearing, seals, couplings
3	Gearbox and lubrication	Gearbox, lube pump, cooling system
4	Generator and cooling	Generator, power converter, cooling system
5	Brakes and hydraulics	Hydraulics, callipers, shoes
6	Yaw system	Callipers, wear pads
7	Control system	CPU, interface modules, sensors
8	Electrical and grid	Contactors, circuit breakers, relays, capacitors
9	Miscellaneous	Hardware, other small mechanical, hydraulic and electrical parts not identified specifically

6.9 Consumables

Parts and supplies that are required for scheduled service, as opposed to repairs, are considered consumable. This category includes lubricants, filters, and cooling fluids. Parts such as brake pads and generator bushes, which are replaced indeterminately, are included in the parts category.

Annual turbine services generally include filter elements and greasing of the main bearing, yaw bearing and gear, pitch bearings, and generator bearings. Gear oil is mineral, as opposed to synthetic, and, according to common practice, should be replaced every three years. The model assumes an offline gear oil filter system and annual oil sampling. Hydraulic fluid will be replenished as required; this is generally a minor expenditure. See Annex-D for annual consumable cost estimates for pre-turbine in Birr.

6.10 Establishment of O&M Plan

6.10.1 O & M Tasks

Operation and Administration

This category includes tasks associated with scheduling turbine crews, ordering and receiving parts for inventory, monitoring turbines status and performance, scheduling outside services for site maintenance, coordinating with the interconnect provider for outages and cutting, and generating status and production reports. Since the most time-consuming activities are linked to the number of turbines, the model assumes that the manpower required for this activity depends only on the number of installed turbines, as opposed to the size of the turbine or the total capacity.

RPSs Water Boards typically contract outside service organizations to provide some or all of the O&M services, especially in the early years of a project. After several years, the Water Boards may then decide to self-manage the system by Water Administration Office. Specialty tasks that require specific training or equipment, such as road maintenance or transformer inspections, are usually hired out. Depending on the workload caused by repair activities, a project may contract an outside service to perform biannual turbine servicing. This is not necessarily a less expensive option per turbine, but it does allow the

Water Boards to focus trained technicians on the difficult tasks and avoid hiring additional permanent staff.

O&M Tasks include:

- Patrol perimeter fence and repair,
- Check tower frame for damage, loose bolts, or weakness,
- Check condition of pumping rods and securing bolts,
- Grease all grease nipples,
- Check rotor blades are not bent or damaged,
- Measure volume of water delivered by each stroke to check, condition of pump washers
- Replace pump washers,
- Check pipe line from wind pump to tank,
- Test all valves,
- Repaint tower,

6.10.2 Troubleshooting

Trouble shooting is a process which shall be performed to find out a solution for prevailed problem. Before going into trouble shooting process let us discuss the working principle of the system to be familiar with it.

Table 6-2: Troubleshooting for windmill

No.	Problem	Causes	Solution
1	Wind pump does not self furl	Furling mechanism not working	Repair furling system
2	Windmill working but no water being raised	Borehole has run dry Pump washers leaking Leaky riser	Remove pump and Inspect/repair. Use dipper to check water level in borehole

6.10.3 Spares Tools & Technical Assistance

Tools

- Grease gun

Spares

- Grease

- Pump washers

Supply Chain- Grease and other plumbing materials can be purchased at a well provisioned hardware store.

Technical Assistance- Specialized technical assistance may be required to remove pump from borehole.

Specialized technical assistance is required to lower the tower. Specialized technical assistance should be sought if it is suspected that the borehole has run dry. Zone Water Office or Woreda Water Office can ascertain if this is the case.

6.11 Documentation

A Site Visit Checklist that sequentially follows the procedures outlined in the Operation and Maintenance Site Manual is a helpful tool for the field technician. It ensures that all required operation and maintenance tasks are successfully completed, and serves as an historical record of a site's quality control, quality assurance, and operational activities.

These are directly related to your claims of data validity. The value of this document becomes evident when a reconstruction of past events becomes necessary. A precise, detailed information record can help explain any periods of questionable data and may prevent significant data from being discarded.

For these reasons, a standardized Site Visit Checklist should be developed, completed for each site visit, and kept on file. Example information and activities to detail in the checklist include:

- **General Information:** Site name, technicians, date and time of site visit, and work to be performed.
- **In-House Preparation:** List of necessary tools, equipment and supplies (including spares), documentation, maps, and safety items.
- **On-site Activities:** A sequential list of the various site activities, including equipment checks, data retrieval, tower-related work (raising and lowering procedures), and departure activities.
- **Findings and Recommendations:** A detailed account of the work performed, findings, and observations, and if applicable, further required or recommended actions.

A sample Site Visit Checklist is presented at annex -F.

Annexes

Annex M: Wind Speed versus Power Density

Wind Speed	m/s	**2.5**	**5**	**7.5**	**10**	**15**	**20**	**30**	**40**
	km/h	9	18	27	36	54	72	108	144
Power Density	kW/m^2	0.01	0.08	0.27	0.64	2.2	5.1	17	41

This indicates the very high variability of wind power, from around $10W/m^2$ in a light breeze up to 41 $000Wm^2$ in a hurricane blowing at 144km/h. This extreme variability greatly influences virtually all aspects of system design. It makes it impossible to consider trying to use winds of less than about 2.5m/s since the power available is too diffuse, while it becomes essential to shed power and even shut a windmill down if the wind speed exceeds about 10-15m/s (25-30mph) as excessive power then becomes available which would damage the average windmill if it operated under such conditions.

Annex N: Variation of Air Density with Altitude

Altitude a.s.l.(m)	**0**	**760**	**1 520**	**2 290**	**3 050**
Density correction factor	1.00	0.91	0.83	0.76	0.69

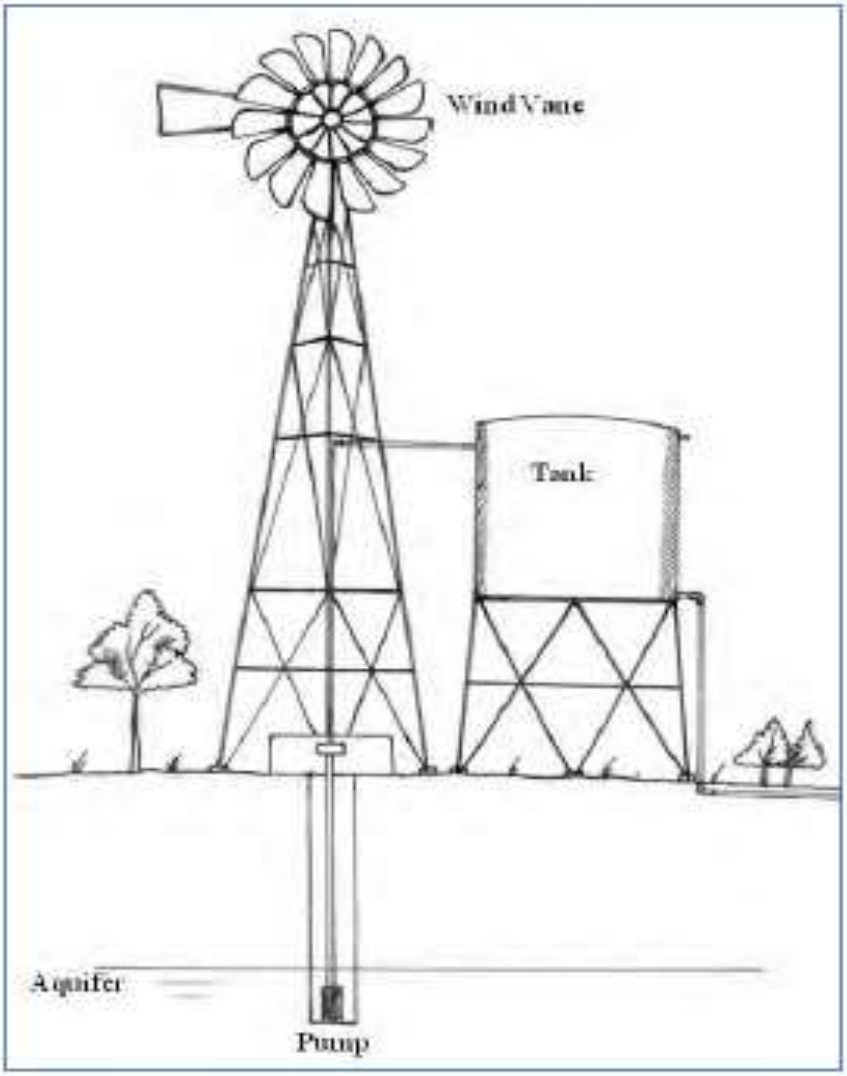
Annex O: Calculation of Wind Pump Output Using "Binned" Wind speed Data

Annual Output of Water for a given wind regime				
Wind speed		**Annual duration hours**	**Output rate m^3/hr**	**Total Output m^3**
m.p.h.	**m/sec**			
7	3.15	600	0.3	180
8	3.6	500	1.4	700
9	4.05	500	2.3	1,150
10	4.5	400	3	1,200
11	4.95	500	3.7	1,850
12	5.40	450	4.2	1,890
13	5.85	450	4.7	2,115
14	6.30	300	5.2	1,560
15	6.75	300	5.7	1,710
15 plus		1,700	6	10,200
	Total	**5,700**		**22,555**

Annex P: Per-Turbine Annual Consumable Cost Estimates (Birr)

Turbine Size	750 kW	1 MW	1.5 MW	2.0 MW	2.5 MW
Gear oil filter, ea	2,000	2,660	4,000	5,340	6,660
Hydraulic filter, ea	2,000	2,000	2,000	2,000	2,000
Offline filter, ea	2,000	2,000	2,000	2,000	2,000
Hydraulic oil, @$40/L	400	400	400	400	400
Gear oil, @ 3.70/L	2,800	3,800	5,580	7,420	9,280
Yaw gear grease @15/tube	1,200	1,700	2,400	3,200	4,000
Bearing grease @ $10/tube	900	1,200	1,800	2,400	3,000
Oil testing, ea	2,400	2,400	2,400	2,400	2,400
Electricity	14,000	17,600	26,280	35,040	43,800

Annex Q: Typical Wind Pump with Service Reservoir



Annex R: A sample Site Visit Checklist

iv. General Information

Site Designation		
Site Location		
Crew members		
Date(s)		
Time (LST)	Arrival:	Departure:
Visit Type (Check)	Scheduled ☐	Unscheduled ☐
Work Scheduled		

v. In-House Preparation

Check each box to denote the items have been acquired.

☐ In-house support person:_____

☐ Copy of Site Information Log.

☐ Acquire necessary tools, equipment, and supplies.

- ☐ Electrical supplies: voltmeter, fuses, tape, connectors, cable ties, batteries, crimpers, etc.
- ☐ Wrenches, pliers, screwdrivers, nut drivers, hex set, sledgehammer, wirecutters, etc.
- ☐ Misc. equipment: silicon, magnetic level, binoculars, camera, GSP, etc.
- ☐ Spare equipment: cabling, anchors, booms and mounting hardware, etc.

- Sensors:

  (1) Sensor:_____ Serial #_____ Slope/Offset:_____/_____

  (2) Sensor:_____ Serial #_____ Slope/Offset:_____/_____

  (3) Sensor:_____ Serial #_____ Slope/Offset:_____/_____

- • Data logger: Serial Number_____

☐ Road and topographic site maps

☐ Rental equipment: jackhammer w/compressor, truck/trailer, etc.

☐ Winch with 12V battery and battery charger.

☐ Gin pole and associated hardware.

☐ Safety equipment: Hard hats, gloves, appropriate clothes, first aid kit, etc.

☐ Manufacturer's manuals for installation and troubleshooting (sensors, datalogger etc.)

Additional Information/Comments:
_____
_____
_____
_____
_____

Site Designation:_____

vi. General On-Site Activities

Check the appropriate box. If No, provide an explanation below.

- **General Visual Inspection**

Yes	No	Area free of vandalism?
Yes	No	Tower straight?
Yes	No	Guy wires taut and properly secured?
Yes	No	Solar panel clean and properly oriented?
Yes	No	Wind sensors intact, oriented correctly, and operating?
Yes	No	Ice or snow on sensors, solar panel, antenna?
Yes	No	Grounding system intact?
Yes	No	Cellular antenna correctly orientated?

Findings/Actions:_____
_____
_____

- **Data Retrieval**

Manual Remote Download method

Yes No Successful download? If No, provide explanation below.

Findings/Actions:_____
_____
_____

- **Datalogger Inspection** (Check when completed)

Yes No Data logger operational? If No, provide explanation below.

Check the appropriate box. If No, provide an explanation below.

- **General Visual Inspection**

Yes ☐ No ☐ Area free of vandalism?

Yes ☐ No ☐ Tower straight?

Yes ☐ No ☐ Guy wires taut and properly secured?

Yes ☐ No ☐ Solar panel clean and properly oriented?

Yes ☐ No ☐ Wind sensors intact, oriented correctly, and operating?

Yes ☐ No ☐ Ice or snow on sensors, solar panel, antenna?

Yes ☐ No ☐ Grounding system intact?

Yes ☐ No ☐ Cellular antenna correctly orientated?

Findings/Actions:_____
_____
_____

- **Data Retrieval**

Manual ☐ Remote ☐ Download method

Yes ☐ No ☐ Successful download? If No, provide explanation below.

Findings/Actions:_____
_____
_____

- **Data logger Inspection** (Check when completed)

Yes No Data logger operational? If No, provide explanation below.

☐ Record system voltages:_____

☐ Date displayed:_ _____ Actual:_____ Corrected? (Circle) Yes / No

☐ Time displayed:_____ Actual:_____ Corrected? (Circle) Yes / No

Yes ☐ No ☐ Check sensor values, are they reasonable? If No, provide explanation below.

Findings/Actions:_____
_____

- **Tower Lowering Activities**

  Yes ☐ No ☐ Check all anchors, signs of movement?

  Yes ☐ No ☐ Winch secured to anchor and safety line connected to vehicle bumper?

  Yes ☐ No ☐ Gin pole assembled with safety cable and snaplinks taped?

  Yes ☐ No ☐ Tower base bolt tight?

  Yes ☐ No ☐ Gin pole safety rope attached and tensioned properly (gin pole straight)?

  Yes ☐ No ☐ Weather conditions safe?

  Yes ☐ No ☐ Note start time of tower lowering. _____(CST)

  Yes ☐ No ☐ Winch battery connected and terminals covered?

  Yes ☐ No ☐ Lifting guy wire attachments to gin pole checked?

Findings/Actions:_____
_____
_____

- **On-Ground General Activities**

  Yes ☐ No ☐ Sensor and ground wires securely attached?

  Yes ☐ No ☐ Grounding system intact and secure?

  Yes ☐ No ☐ Sensor boom clamps secure?

  Yes ☐ No ☐ Boom orientation OK?

  Yes ☐ No ☐ Boom welds OK?

  Yes ☐ No ☐ Vane deadband orientation as reported on Site Information Log?

  Yes ☐ No ☐ Sensors level and oriented correctly?

  Yes ☐ No ☐ Sensor wire connections secure and sealed with silicon?

  Yes ☐ No ☐ Signs of sensor damage?

  Yes ☐ No ☐ Sensor outputs checked and functioning properly?

  Yes ☐ No ☐ Sensor serial numbers as reported on Site Information Log?

  Yes ☐ No ☐ Sensor and/or data looger replacement? If Yes:

- **Sensors:**

(1) Sensor:_____ Serial #:_____ Slope/Offset:_____/_____ Height:_____

(2) Sensor:_____ Serial #:_____ Slope/Offset:_____/_____ Height:_____

(3) Data Logger:_____ Serial #:_____

Findings/Actions:_____
_____
_____

- **Tower Raising Activities**

Yes No _ Guy wire collars positioned correctly?

Yes No _ Lifting lines and anchor lines properly attached?

Yes No _ Gin pole secure, lines tensioned, gin pole straight, snap links taped?

Yes No Weather conditions safe?

Yes No Guys properly tensioned?

Yes No Tower straight?

- **Note on-line time :_____(LST)**

- **Site Departure Activities**

Yes No Successful data transfer with office computer?

Yes No Check antenna and phone connections?

Yes No Is datalogger date/time correct?

Yes No Secure datalogger enclosure with lock?

Yes No Clean area?

Yes No Guy wires clearly marked?

Findings/Actions:_____
_____
_____

iv. Findings and Recommendations

Yes No Further actions required? If Yes, describe below:
_____
_____
_____
_____

Solar and Wind Energy

Pastoral Area Water Supply

(Parts E, F, G, H)

Solar and Wind Energy, Community and Financial Management of the Pastoral Areas

PART – G: COMMUNITY BASED SCHEME MANAGEMENT IN PASTORAL AREAS

Document 10

PART – G: COMMUNITY BASED SCHEME MANAGEMENT IN PASTORAL AREAS

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7. COMMUNITY BASED SCHEME MANAGEMENT

7.1 General

The sustainability of the development effect is one of chief concerns among stakeholders including the sustainable functioning of the water supply schemes constructed. The sustainable Operation and Maintenance (O & M) and management of water supply schemes primarily depend upon the capacity of the beneficiary (or users') communities accompanied with discharging their responsibilities and confidence. The realization of these conditions requires considerable time and efforts to be made through continued interactions among all stakeholders concerned, particularly the target users' communities and Woreda officials. In this respect, the Woreda Water Office (WWO) are expected to perform their tasks through which those users' communities are expected to be encouraged and empowered into self-organization for sustained operation and management of water scheme.

In the past, in many cases, constructed water schemes had considerable problems; there was poor usage and maintenance of water supply schemes, eventually broken down, because the user communities did not feel that they owned the water scheme, they did not take responsibility of management and O & M, the water supply schemes were installed without their involvement. Recent experiences have shown that water schemes are effective management system much depends on regular management and monitoring and close communication between the administration (WWO) and the beneficiaries.

This manual is prepared to establish solid community-based management system through capacity building of water user communities represented by Water, Sanitation and Hygiene Committee (WASHCO) particularly in pastoral areas.

The basic principles behind this concept which have been accepted by government and donor agencies is that the community that benefits from an improved water supply and sanitation should:

- Have a voice & choice in its developments,
- Own the water system or facility, and
- Have overall responsibility for its Operation and Maintenance Management (O&MM).

The outcome of the participation of the community in the O&MM is to enhance sustainability of water supply schemes. In line to this, the involvements of the community have been fulfilled through the formation of WASHCO that is responsible for O&MM the system, setting and collecting water tariffs and managing maintenance and repair activities.

The manual was developed to improve community based O&MM to foster the way for benefiting community to advance their management practice and hopefully increase the likelihood of sustainable water supply scheme.

The assessment conducted under this project revealed that the community based scheme management and well as support for Government body was found very minimal. Thus, this manual will assist the regional water bureaus, zone and woreda water office to capacitate and built the ability of the WASHCOs to manage their schemes.

This community based scheme management training manual basis on documents reviewed from different sources, personal and water sector development experience of the Country as well as consultation with various stakeholders in the sector. In this manual the consultant has attempted to question the widespread faith placed in community management, to determine under what conditions it can contribute to sustainable rural water services.

7.2 Purpose of this Manual

This manual is prepared as field implementation manual for WWO and WASHCOs for managing point sources who takes responsibility of daily operation, maintenance and management of the water scheme. This manual, as management back-up-knowledge and references, focuses on areas of organization and management.

[Specific Objectives of the Manual]

- To provide general idea on community-based management with WASHCO
- To provide basic and practical knowledge & skills on how to manage and maintain the completed water schemes whish are necessary as daily water scheme management
- To provide minimum but basic and essential knowledge on hygiene and sanitation as one of promoter of appropriate sanitation and hygiene practice in the community.

7.3 Scope of the Manual

This manual is mainly developed for pastoral areas community based scheme management both for point water sources and rural piped system.

The Manual focuses on building understanding, knowledge and skills within the community members and their management structures on a range of organisational, legal, financial, and technical issues relevant to operating the water supply infrastructure efficiently and effectively in order to provide an improved and sustainable water supply.

7.4 Definition of Community terms

It is necessary first to define what community mean? the extent of community participation, what do we mean when we say community management and their roles in WASH.

7.4.1 What is a “Community”?

We have been talking a lot about “COMMUNITY”, but what or who do we mean by “COMMUNITY”?

We are talking about a “WATER USER COMMUNITY” - people who live around the water supply schemes such as a hand dug well, a shallow well, a borehole or a spring or a dam or Berkads or rainwater harvesting, a or piped system and share the use of these facilities. They form a “community” – they are neighbours, draw water from the same water point, and can work together to improve their water, sanitation, and hygiene and manage the system.

For a point water source (e.g. HDW, SW or BH scheme) the “WASHCO” will be small - **people living in one section of a village**. For a piped scheme, the “water user community” will be large - **members of a whole village or several villages**.

User communities will take the lead to develop water supply and sanitation facilities for their own areas. They will come together, work out what they want, and apply for help to develop these facilities.

So the "COMMUNITY" is YOU – you and your neighbours.

Let's start talking about:

- Problems with the existing water supply and sanitation facilities
- How can you improve these facilities and hygiene habits
- How you can work together to plan and make these improvements.

7.4.2 Community Participation

Community participation can be defined as "an active process whereby beneficiaries influence the decision and execution of development project rather than merely receive a share of project benefit". Community participation is needed in making decisions about project site, technology and rules for governance.

The services are effective when the community have a voice and choice in selecting committees, establishing tariff rates and establishing hours of operating the service. Voice and choice is a technique in which the end users have a say in what is done in planning and implementing a facility or system.

7.4.3 Community Management

Community management refers to the capacities and willingness of users to change and determine the nature of development affecting them. Thus, in RPS system community management refers to the level at which the community exercise responsibility for decision making and control over subsequent education of these decision during project development and a capability of a community control and strongly influence the development of its water supply schemes, which has three basic components:

- **Responsibility:** the community takes on ownership of water supply system and attendant obligation to the system,
- **Authority:** the community has the legitimate right to make decision regarding the system on behalf of users,
- **Control:** community is able to carry out and determine the outcome of the decision.

In general community management is concerned with all issues pertaining responsibility i.e.

- Ownership,
- Decision making authority and,
- Control over project development and systems operations,

This may imply a variety of management systems from extensive contribution of self-help labour at lower levels of service to specialized managers at higher levels of services.

Thus, the decision making requirements apply not only to the male leadership but also and perhaps particularly to village women. Women lack of schooling and literacy skills

should not prevent them from making valuable contributions to community decision making. The important preconditions for effective community management are:

- Community demand driven for improved water supply,
- The availability of information, which required to make informed decision to the community,
- Technologies and level of service with the community's needs and capacity to finance, manage and maintain them,
- Understanding of the community in technological and willingness to take responsibility for system,
- Willingness to invest in capital and recurrent costs,
- Involvement of the community to make decision and choice,
- Community institutional capacity to manage development and operation of the system and human resources to run this institution,
- Policy which permit and support community management.

Continues external and internal support and service availability from the government, NGOs and private sectors (like training, technical and credit service…), these it does not mean that the users do everything themselves.

7.4.4 Difference and similarity between Community Participation and management

Community participation and management distinguished on the basis of fee collecting activities. Community participation implies that the community performs routine operation all duties such as record keeping, accounting and payment collecting under a system predefined by external agency, where as community management implies that in addition the community establishes tariff schedules and institution establishes its own form of collection.

7.4.5 Why Community Management?

Experience in many developing countries during and since the international drinking water supply and sanitation Decade, (1981 - 1990) shows that even the best run water agencies cannot successfully implement, operate and maintain a network of widely dispersed water systems without the full involvement and commitment of the users. Despite the best endeavours of central agencies; staff, transport and budgets become overstretched, leading to broken down systems, dissatisfied consumers and demoralized agency personnel.

Properly continuously supported communities have both the ability and the willingness to manage their own water systems. Agency resources currently swallowed up in the provision and maintain of inefficient services can thereby be diverted to a much more effective facilitating role, bring greater cost effectiveness and more widespread and sustainable benefits. The major reasons why a community – management approach has been adopted on rural pipe system scheme management and sanitation projects are:

1. Reliability, sustainability and replicability

2. Stimulus to community development and

3. It works

7.4.5.1 Principle of Community Based Management

The World reached the era of the trained community manager. Those that run communities for organizations will be expected to know what they're doing, not learn on the job. They know the theory behind their work. They know the case studies of success and failure. They test, measure and adapt. They work to understand what is/isn't working (and why). In communities, professionals will be expected to excel in key skills. They will be expected to guide their organization through the community management process. They will be expected to prove their value numerically. Successful amateurs will still thrive, but organizations will want the reliability of the proven. The principles of trained community management are:

1. Trained Community Managers build a strong sense of community amongst a specific group of individuals and to other stakeholders.

2. Trained Community Managers work from proven templates to sustain their water supply scheme through the community management process (they are proactive, not reactive).

3. Trained Community Managers excel at building relationships both with and between members.

4. Trained Community Managers master their data and use their data to optimize every activity and stage of the membership life cycle.

5. Trained Community Managers have deep knowledge of technology, financial management and conflict resolution.

6. Trained Community Managers build internal and external systems to scale their communities without incurring a large financial burden.

7. Trained Community Managers integrate the community with the organization's systems.

8. Trained Community Managers excel at stimulating and sustaining high levels of participation per member.

9. Trained Community Managers excel at conflict resolution and work from proven techniques to resolve potentially detrimental disputes.

10. Trained Community Managers deliver a clear role and responsibility to their employers (not fuzzy statements concerning engagement*)*.

These principles might change over the next few years, but it is a good start. If you're hiring a community manager, does this sound like the type of person you would like to hire?

7.4.6 Role of Community

In the past, Government took the lead role in planning and developing water facilities:

- Government **decided** which communities should get new facilities.
- Government **financed** all the costs for the new water facilities.
- Government **sited, planned,** and **constructed** facilities.
- Government **maintained** and **repaired** facilities.

The community was left out of planning and decision-making and are not sufficiently motivated to pay for the facilities. **So the community did not feel they owned the water supply facilities.** They saw them as belonging to government. When the facilities broke down, the community did nothing. They waited for government to come and repair them.

Government saw that it could no longer construct and maintain facilities all over the country – and saw that communities *could* take this over, if given a chance.

This new approach gets **the community to take the lead role**.

Before the water facilities are built, the community will –Decide they want to develop safe water facilities

- Apply for assistance and plan the facilities,
- Decide the type of facilities and how they want to manage them,
- Contribute money, labour and materials towards the cost of construction,
- Supervise and help with construction,
- When the facilities have been constructed, the community will
    - Own the new facilities and look after them,
    - Repair them when they break down and make regular check-ups,
    - Contribute money for spare parts and repairs.

7.4.7 What is WASHCO?

Water, Sanitation and Hygiene Committee, usually shortened as “WASHCO”, is a management committee made up of about 5 to 7 even in some place up to 9 people (the number can vary) who live in the user community area and elected by the community to represent the community in all matter of WASH facilities.

7.4.7.1 General Responsibilities and Tasks

Box 7-1: General responsibilities and tasks of WASHCO

The job of this committee is to take the lead in managing the water supply facilities. They have a number of responsibility and tasks:

- To ensure that the water facility is serving the community safe and adequate water.
- To collect water tariff.
- To deposit its income at the bank or any relevant financial institution like Micro-Financing Institute that is determined in the General Assembly in consultation with Woreda Water Office (WWO).
- To employ water supply scheme personnel, if necessity is arisen, and set salary and obtain the approval of the users' assembly.
- To make regular and close communication with WWO on any issues related to O & M and management of water scheme
- To make regular monitoring report on the O & M and management of the water supply scheme to WWO
- To prepare work plan for the rehabilitation the water supply facility in consultation with WWO.
- To implement work plan upon the approval the work plan by the General Assembly.

7.4.8 Formation of WASHCO

7.4.8.1 Preparatory Meeting with Community Leaders

There is a need to hold a preparatory meeting with community key persons (leaders) in order to prepare for the users' meeting.
The objective of the meeting with community leaders is just to establish good relation with supportive community leaders and they are a way to sensitize and mobilize the community to involve in.

Procedures to be followed:

- Contact supportive persons of the target community such as kebele executive, kebele chairperson
- Explain the outline and the objective of a project/program
- Ask about diseases and needs and what solutions have been applied
- Ask if they have suggestions for improvement of the situations which have not yet been discussed with the community
- Find out how much they know about the links between water, sanitation practices and diseases

- CPP visit around the compound and surroundings to observe the community
- Fix the place and the time for next meeting (community consultative meeting)

Some practical tips:

- The importance of women's participation can be emphasized from this occasion.
- The time and the place need to be arranged in consideration with the time and the place convenient for women.

7.4.8.2 Consultative Meeting with Users (Formation of WASHCO)

The main objective of conducting consultative meeting with the users':

- To enable prospective water supply scheme users to understand the importance of WASH
- To enable them to understand the community-based management and
- To form a WASHCO through community consultation

Expectations from the participants

- At least of two thirds (2/3) out of a total user household heads have to attend that mass meeting.
- All community members should be invited to the community meeting, but extra care should be taken that any of the following categories are not forgotten.
  - Village leaders, traditional chiefs and elders
  - Prime Users – Women
  - Existing HEW and HAD
  - Representatives of existing WASHCOs and groups

Procedure to be followed:

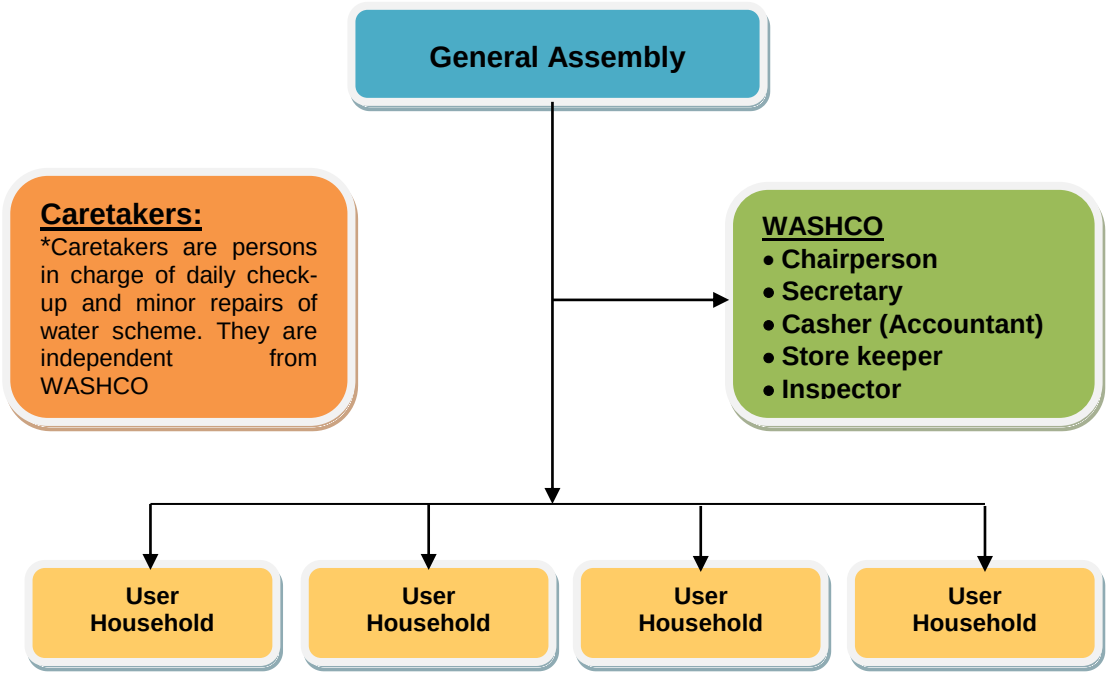
- Explain the outline and objective of a project/program
- Ask about diseases and needs and ask what solutions are already applied
- Ask if they have suggestions for improvement of the situations which have not yet been discussed with the community
- Find out how much they know about the links between water, sanitation and hygiene practices and diseases
- Explain the concept of community-based management
- Explain the role and responsibilities of WASHCO (refer to basic idea on WASHCO described in the next page)

- Elect WASHCO members according to the criteria decided by the participants (see the next page about how to elect the WASHCO members)

7.4.9 Structure of WASHCO

In general, five (5) to seven (7) members shall be elected in the community mass consultative meeting for WASHCO who manage the point-source type water scheme such as hand duh well, shallow well/deep well with hand pump, on-spot spring, berkads. In case of piped line water scheme, a committee is also formed at each water point (like tap committee).

Figure 7-1: Structure of WASHCO for Point Water Sources



7.4.9.1 Committee Composition and Member

i) Composition

Among the committee members at least three of them (more than 50%) should be women and should play key managerial role. This is due to the fact that the woman bear the maximum burden of water related activities.

ii) Members

The committee shall have the following members:

1. Chairperson
2. Secretary
3. Cashier/treasurer
4. Store keeper,
5. Inspector

7.4.9.2 Gender aspects of the WASHCO's

A balance of men and women on WASHCO's may help to achieve, but not necessarily ensure, an equitable division of work and responsibilities between men and women. The aim is to avoid either men or women doing all the work or making all the decisions. Gender often plays a role in the division of tasks. A man usually chairs a committee but a woman may be secretary or treasurer. Widespread experience indicates that women treasurers often perform better than men but appropriate training is required.

The *Dalocha* in SNNP region and Etege Tayitu in Amhara region water supply schemes fully managed by women, which is an exemplary O&M management, indicated that women are responsible to manage the schemes.

7.4.9.3 Task of WASHCO Members

General tasks assigned to each member of WASHCO are described in Table 7-1.

Table 7-1: General tasks assigned for WASHCO members

No.	Members	Duties and Responsibilities
1	**Chairperson**	▪ Provide leadership to the overall WASHCO/WUB activities ▪ Approve payments ▪ Supervise the activities of the cashier ▪ Order purchase of Spare parts ▪ Ensure the collection water tariff and other incomes ▪ Arrange services for maintenance in consultation with Woreda Water Office. ▪ Facilitate the proceeding of general assembly of the community ▪ Hold regular WASHCO/WUB meeting as well as ad-hoc meeting when necessity arises ▪ Attend meetings at Woreda or Regional levels representing the WASHCO/WUB. ▪ Make official communication and sign on behalf of WASHCOs with public institutions, NGOs and private firms representing the WASHCO.
2	**Secretary**	▪ Prepare the minutes of meetings of the general assembly as well as of regular and ad-hoc WASHCO/WUB meetings ▪ Perform all activities of the chairperson in his/her absence. ▪ Prepare receipts for collection of incomes ▪ Prepare payments and submit for approval of the chairperson ▪ Record all incomes and expenses in account book ▪ Make sure that collection of incomes and effect of payments shall be made only by the cashier. ▪ Prepare monthly and quarterly performance and finance reports of WASHCO/WUB for approval of the chairperson

No.	Members	Duties and Responsibilities
		▪ Keep all financial and administrative records of WASHCO properly ▪ If the deposit of the WASHCO/WUB is at bank or approved institution by general assembly, he/she will be co-signatory with the chairperson and the cashier. ▪ In case of cash payment, he/she will be co-signatory with the chairperson. ▪ Prepare, contract agreements with service providers
3	**Cashier (Treasurer)**	▪ Collect water fees or other incomes based on the receipts ▪ prepared by secretary ▪ Effect payments in accordance with approved documents, by chairperson and secretary. ▪ Keep the bank deposit slips or approved institution for record ▪ Request petty cash for immediate expenses for O & M of the water scheme, the amount shall be fixed by the general assembly. ▪ Keep all the documents at hand properly for inspection and auditing.
4	**Store Keeper**	▪ Keep the properties of the water facility by registering in the format prepared by Woreda Water Office. ▪ Issue items upon the approval of chairperson and secretary. ▪ Prepare report on the status of fast moving items for replacement and purchase. ▪ Keep all records in proper for inspection and inventory
5	**Inspector**	▪ Inspect the financial management of WASHCO. ▪ Supervise the proper utilization of purchased items ▪ Check the monthly water consumption and respective income. ▪ Ensure the expenses of WASHCO are as per the set acceptable procedure and regulations. ▪ Act as internal auditor. ▪ Inspect the records of secretary and cashier. ▪ Prepare a report on the overall water supply management of the water scheme. ▪ Present the report to the general assembly

7.4.9.4 How to elect WASHCO members?

❖ **Whom to elect?**

- **Is the participation of main water users (often they are women) promoted?**

  The election meetings must be announced indicating that the participation of water users i.e. mainly the women should be promoted. Traditionally, mainly the men are participating in decision-making meetings. If more men attend, mainly the men will be elected.

  Special care need to be taken to explicitly announce that it is desirable that those actively collecting water and thus using the source are participating in both the election and the committee. If a committee comprises only of men who never go to the source, they are not likely to discover anything wrong with it and take early action.

- **Are more users given chance to be candidate of members?**

  Another risk is that unless people are specifically sensitized to the need for having actual users in the committee, very often the existing local leaders are often appointed, although they may not have the time to participate fully. A local spread of responsibilities will increase democracy and strengthen capacity and responsibility.

- **Is committee representative of all users?**

  This is the best way to avoid dormant or dying committees. Members who drop out also need to be promptly replaced. The committee should if possible be representative of all users. The community selects representatives of:

  - Different socio-economic groups
  - Different education
  - Different ages
  - Both men and women (50%-50% is desirable!)
  - From existing groups

- **What are criteria to select effective WASHCO members?**

  To select effective members of WASHCO, the following criteria are to be fulfilled.

  - Good ethics, example to the other community members
  - Responsible and honest
  - Have good motivation to work for sustainable community water supply
  - More than 18 years old
  - At least 5 years living in the community
  - Able to read and write
  - Willing and able to spare enough time to serve the community including promoting appropriate sanitation and hygiene practices in collaboration with health extension workers
  - Permanent user of the water scheme
  - Free from corruption and prioritize the benefit of the community rather than personal interest

- Positive to make the by-law of the water scheme acceptable for the community.

7.4.9.5 What is tenure of WASHCO members?

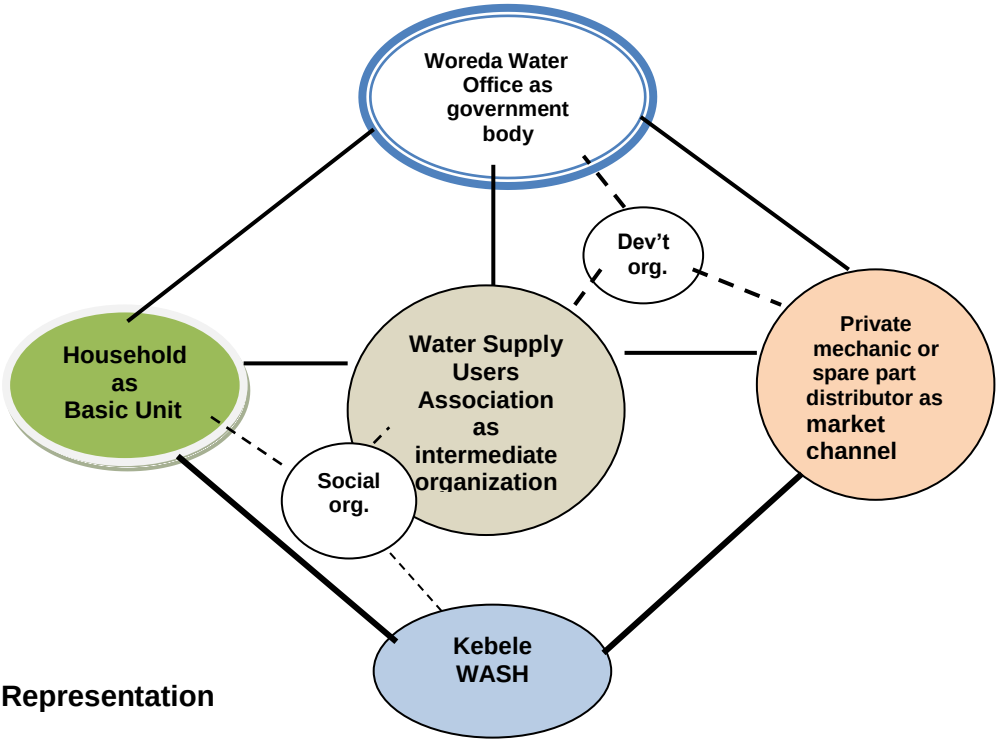
It is better to elect members every three year at maximum in order to introduce "democratic management", in other words, to avoid "monopolized management".

Many experiences have shown that if same members keep same positions, they may consider the water scheme as their own property. Then, the democratic management system tends to be more corrupted.

7.4.9.6 Position of WASHCO to other stakeholders in the community

Main actors in acquisition, utilization and management of water and human resources can be categorized into seven organizations (or groups of people); (i) Woreda Water Office as government body; (ii) private area mechanics or spare-part distributors available in local market; (iii) Kebele as community governance body; (iv) individual household as users; (v) social organization that maintain human relations in peace and order including *Idir* or religious organization; and (vi) Water Supply Users Association (including WASHCO) as intermediate organization through which relevant interactions take place for consensus building, technical interventions and resources supplement that are needed to ensure sustainability of operation and management of individual water supply facility. In other words, the prime role of Water Supply Users Association is to combine social consensus among main actors, technical ideas and resources into one function of sustained operation and management. Figure 7-2 below presents WASHCO's relation with other relevant stakeholders.

Figure 7-2: Demonstration of WASHCO in relation to other stakeholders



7.4.9.7 Equal Representation

Gender relates to both men and women. A gender based approach looks at the social differences between men and women to seek a balance, which optimizes the roles and responsibilities of both men and women.

Box 7-2: Why should there be equal gender representation in the WASHCO?

- Women are the principal users of a water system. It is in their interests more than anyone else for the water system to function properly.
- As principal users of water, women are the best judges of the most suitable standard of service required (e.g. when water point should be open) and are the first to recognise problems.
- Women have considerable knowledge of existing water sources, the amount of water, which ones are seasonal and perennial, information that is very important at the planning stage.
- Women and men's opinions and preferences may differ. It should not be assumed that an all-male committee will always represent the best interests of all users of a water system.
- Women are less likely to leave the village to seek work.

7.4.9.8 What is Gender?

Gender relates to both men and women. A gender based approach looks at the social differences between men and women to seek a balance, which optimizes the roles and responsibilities of both men and women.

7.4.9.9 Why is a gender approach relevant?

Women are the managers of water and sanitation at the household level. It is women who spend up to several hours per day on the task of fetching water. It logically follows that in order for a water system to adequately meet the needs of its beneficiaries; women should not only be consulted but should also be actively involved from the project planning stage through to completion and operation of the system. However it is common that water management committees, who take decisions related to planning and management, consist only of men.

7.4.9.10 Evaluation and Re-Election of the Committee

The beneficiary community and the Woreda Water Office shall evaluate the performance of the committee. If the member of the committee fails to discharge its duties and responsibilities the general meeting shall be called and re-election shall be undertaken.

7.4.9.11 Legal Status of WASHCO

The legal status of WASHCO is based on specific authorities given to them by the regional state which shall be based on the general guideline of the MoWE or otherwise the Country's Water Resource Management Policy.

7.4.9.12 Handing Over

Every WASHCO member shall handover to the concerned body all documents and materials that may belong to the WASH scheme on termination of the committee

membership for different reasons. The handover activity shall be done using the handover format and at the presence of Woreda Water Office representatives.

7.4.10 Formulation of By-Law

The by-law is a summary of ground rules for the use and the management of the water scheme and management. The formulation of the by-law is an important step to have water users consider the water scheme as their own property by discussing different topics related to the use and management of water scheme in a mass meeting.

Table 7-2: Procedures in the Formation of By-Law

Activity	Formulation of By-Law
Objective	▪ To establish common rules and basis of management of water scheme through participatory and democratic way
Main Organizers	▪ WASHCO with assistance from Woreda Water Office staff
Timing	▪ During the planning (before starting operation)
Expected Participants	▪ At least of two thirds (2/3) out of a total user household heads have to attend that mass meeting ▪ All community members should be invited to the community meeting such as village leaders, prime users (women), kebele executive and kebele chairperson as mentioned earlier
Procedure	▪ Explain the objective of a meeting ▪ Woreda Water Office staff explains topics to include in the by-law. ▪ Woreda Water Office staff facilities participants to discuss and decide operation and management rules. One of WASHCO members (e.g. secretary) keeps notes. ▪ After completion of the draft by-law, one of WASHCO members (e.g. secretary) read all the points decided for approval of the participants.
Tips!	▪ This session requires sufficient time (does not need to be completed in a hurry) so as to allow users to consider the water scheme as their own property by discussing different rules. ▪ In this regard, if one session is not enough in consideration of the understanding level of the participants and their time available, it is recommended to divide into two sessions.

See Annex – A for sampled by-law for WASHCO's.

7.4.10.1 Types of meetings in the WUA By-law

The WASHCO/WUA meetings can be divided in to 4: i) Executive Water Board meeting, ii) Sub-committee meeting, iii) Annual General Meeting and iv) Special general Meeting.

Different Types of WUA Meetings

1. *Committee Meetings*

   - Held regularly, e.g. once every month by the project committee members;
   - To discuss matters mainly concerning administration of the project.

2. *Sub-Committee Meetings*

   - A project committee may divide itself into various subcommittees;
   - They hold their meetings as necessary to discuss specific matters of the project

3. *Annual General Meetings*

   - Organized and called by the committee twice every year;
   - The purpose is to inform members about issues concerning their project accounts and other specific matters (such as elections and project progress).

4. *Special General Meetings*

   - Held when there is special business to be discussed by the members.
   - These meetings are often seen as extra-ordinary meetings.

7.4.11 Procedures for conducting meetings

The followings are the procedure to be considered when conducting meetings:

1. Proper announcement (notice) of the meeting prior to the date of the meeting including the agenda, time and venue of the meeting;
2. Reference to the WUA by-law on matters related to absence of committee members at meetings;
3. Keeping the meeting on agenda points and not deviating into non-agenda issues;
4. Ensuring that Any Other Business (AOB) issues are not treated as agenda items.

Box 7-3: Sequence of Events in a Meeting

1. Chairman calls the meeting to order;
2. Meeting may start with a word of prayer if appropriate;
3. Chairman checks quorum and secretary lists the members present;
4. Chairman checks for members „absent with apologies" – these are noted in the minutes;
5. Chairman checks for members „absent without apologies"
6. Chairman reviews the Agenda which may be:
    a) Read and confirm minutes of last meeting;
    b) Matters arising from the minutes;
    c) Specific agenda items for this meeting.
7. Minutes of previous meeting are read and confirmed or amended;
8. Review Minutes of previous meeting and address any issues or action points that were identified and get a report on progress (except for any issues that are on the agenda for this meeting);
9. Discuss the specific agenda items for this meeting.
    a) The chairman introduces each agenda item and then seeks contributions from members, guiding the discussions until the time for decision making;
    b) The chairman outlines what has been discussed and asks members which direction they want to go;
    c) Members may agree around a certain position. If there is no common agreement, the decision can be made through a vote using various methods;
    d) Once a resolution is made on the matter, the secretary makes a brief summary of the points that were raised and records the resolution in the minutes book and it becomes the official position of the meeting;
    e) The secretary should read the resolution as recorded so that members agree with the wording and meaning;
    f) The secretary should also record clearly if the resolution also states that a certain action should be taken and by whom. This makes „Matters Arising" in the next meeting easier.

10. The chairman will ask each member if they have any other business (AOB). Note that AOB is generally not an opportunity for decision making but rather for raising issues that could be put on the agenda for the subsequent meeting if required or bringing points of information for the leadership team.

11. The chairman will announce the end of the meeting and set the date for the next meeting;

12. It is often good to close with a prayer again as this gives a good rounded conclusion to the meeting.

7.4.12 The decision-making processes

Use this example to illustrate the different stages in the decision-making process.

Stages of Making Decisions

- Gathering the facts
- Consulting those involved
- Making the decision
- Explaining the decision
- Monitoring the process and results of the decision

Discuss the advantages of different types of decision making e.g. Consensus, Ballot, and Secret Ballot. It is useful to discuss when a different form of decision making is appropriate (e.g. secret ballot at an AGM to allow individuals to make their decision free from any pressure).

Difficulties in Decision Making

1. The facilitator should ask the participants to describe various issues that may affect the quality or speed of making decisions.

2. List these points on a flip chart.

3. Brainstorm on ways to minimise or overcome these complications

7.4.13 Minute Taking

Discuss the formats of minutes using various templates and reviewing the minutes of the group if these are available.

Minutes are an important record of WASHCO/WUA meetings and decisions and so should be taken accurately and kept safely.

Minutes are generally taken and kept by the WASHCO/WUA secretary

Decisions may be difficult to make due to the following issues:

- Fear of consequences – "what if the members reject the decision?"
- Lack of information – insufficient information to know with confidence what the options are;
- Conflicting loyalties – when the leader is in more than one WASHCO/CBO/WUA;
- Interpersonal conflict – personal differences;
- Hidden agenda – if individual committee members have personal interests or conflicts;
- Blundering method – making a decision without testing consensus;
- Inadequate leadership – restriction of opinion / discussion;

Box 7-4: Format of Minutes

MINUTES OF XXXXXXX WATER USER'S ASSOCIATION EXCUTIVE WATER BOARD COMMITTEE MEETING HELD ON XX/XX/12007 E.C AT PROJECT OFFICE

Members Present: List of persons present

Members Absent with Apologies:

Agendas of the meeting:

Discussion and decisions made:

7.4.14 Effective Communication

Many WUAs fail to invest sufficient attention to establishing systems for effective communication between the EWB Committee and members or between the WUA and the Woreda or Zone Water Offices. The net result is that poor communication becomes an impediment to the efficient operations of the project.

Communication is a central part of our lives. Verbal or written, or even non-verbal communication is essential to almost everything we do. You communicate your thoughts, your feelings, and your desires. You communicate whether and by how much you like, respect and trust a person. You communicate happiness, uncertainty, delight, and confidence.

Communication is an important tool in managing groups and conflicts. Effective communication skills tend to hold the community together. Free sharing of information is critical to the development of high performing teams. Where information is controlled and manipulated, mistrust and suspicion usually arise.

Some effective channels of communication and information sharing include:

- Public rallies or barazas
- Workshops and seminars
- Drama/role plays
- Interpersonal and informal interactions
- Person to person contacts
- Pictures/posters/charts/billboards
- Audio visual aids e.g. film shows

Reporting is a form of communication. Reporting is the means (verbal and written) of keeping all stakeholders informed. Regular reporting is critical for community development projects. Why should this be planned? Regular reporting on projects of an organization helps to capture and document data and lessons as they happen. Reports also provide a window into the project for people outside the project. What should be included in a project report?

Discuss. When writing a report one should always have in mind the audience of the report and what will be useful for them. It is important to ask:

- What is the objective or purpose of the report?
- Content of the report, i.e. what information is contained in the report?
- Addressee of the report i.e. who the report is written to?
- Areas of interest to be covered i.e. what should be included in the report?
- What should be the key headings and sub-headings?
- What should be the source of the information?
- This topic is more described in Monitoring, Evaluation, Reporting and Documentation Manual.

7.5 Roles and Responsibilities of Main Stakeholders in O&M Management

Implementation and operation and maintenance (O&M) of rural water supply (RWS) activities shall be carried out through a partnership of various key actors. The WASH strategy formally brings together active stakeholders at Woreda level to support the community in planning and coordination of the implementation of RWS throughout the Woreda. This section identifies and recognizes the stakeholders involved at different levels, their roles and responsibilities, and how they relate to one another for implementation and O&M of RWS activities.

The various key players in RWS are located at various levels from the national level down to the community. The table below summarizes the key players and their strategic functions.

Table 7-3: Key Stakeholders in O&M Management of RWS

Level	Players	Focusing on	Roles
Federal Government	MoWE/	Regional Gov Council	Providing policy direction and sourcing funds for capacity building, strategy formulation, Supporting Regions in Programming (new / rehabilitation of water supply and sanitation facilities)
Regional Government	Regional WB	Council	Backstopping in the supply of spares (spare parts), especially for hand dug wells. Technical Support and Monitor ZWO/WWO
Zone	Zone Water Office	Woreda Council	Backstopping in the supply of spares (spare parts), especially for hand dug wells. Technical Support and Monitor to Woreda
Woreda	Council	WWO	Backstopping in the supply of spare parts; Accounting, Planning, Storing of spares
	Woreda Water Office	WASHCO	Implementing Training, Monitoring, Supervision, Reporting & Recommending
	WASHCO	Caretaker	Community Sensitization, Repairing & Monitoring
Community	WASHCO	Water point And individual households	Owners of the water points. Managing & Budgeting of various activities at the water point including organizing meeting, training of community members, arranging for repairs, and scheduling for preventive maintenance

7.5.1 Ministry of Water, Irrigation and Electricity (MoWE)

Box 7-4 described the roles and responsibilities of the Ministry of Water and Energy in the operation and maintenance management of rural water supply schemes.

Box 7-5: Roles and Responsibilities of Ministry of Water, Irrigation and Electricity

- Is responsible for formulating national water policy, strategy and action plans, and for establishing national standards pertaining to spare parts, water quality, water infrastructure and other relevant standards.
- is responsible for supervising and following up on the implementation of O&M policy and strategy instruments as well as overall sector standards. In addition to its regulatory function,
- Provide technical support to Regional Water Bureaus
- Arrange and facilitate the involvement of private sectors in O&M management, and raise the awareness of the private sector on the business opportunities of spare part.
- Facilitates and develops the local production of spare parts.
- In collaboration with the programme prepares training programmes to Regional Water Bureau experts.

7.5.2 Regional Water Bureaus

The Regional Water Bureaus monitors the implementation of the operation and maintenance management procedure. The Bureaus also updates the procedure when required. In addition to this, the Regional Water Bureaus R&R are:

Box 7-6: Roles and Responsibilities of Regional Water Bureau

- Provide technical support to WASHCO/WUB in the preparation of O&M action plan, budget and identification of spare part supply requirement for maintenance within the Woreda.
- Provide technical support to WASHCO/WUB and make all efforts to assure water supply for the community is reliable, adequate and safe for drinking.
- Arrange and facilitate the availability of spare parts for O & M activities
- Based on the selected and approved spare parts management option, the Bureaus facilitates the establishment and strengthens spare part shops at Woreda level
- Again, based on the approved option (if it is through the WWO), sets guideline on the prices of spare parts and bill collection tickets for sell at Woreda level.
- Procures and distributes spare parts and bill collection tickets when requests and delegation come from Woredas.

- ☞ Raise the awareness of the private sector on the business opportunities of spare part.
- ☞ Facilitates and develops the local production of spare parts.
- ☞ Prepares payment guideline for maintenance services to be provided by artisans or their association
- ☞ Provide tools to the WWO and facilitates the availability of necessary documents at Woreda level.
- ☞ Facilitate the legal environment for community management (e.g. WASHCOs' legal entity and others)
- ☞ -Develop regional performance indicators for O&M and monitor their implementation.
- ☞ In collaboration with the programme prepares training programmes to Zonal & Woreda experts.

7.5.3 Zone Water Offices

Box 7-6: presented the Roles and Responsibilities of Zone Water Offices.

Box 7-7: Roles and Responsibilities of Zone Water Office

- ☞ Provide technical support to Woreda Water Office in the preparation of O&M action plan, budget and identification of spare part supply requirement for maintenance,
- ☞ are the supporting arms of the Water Bureaus and are mandated to provide technical support to Woreda Water Offices
- ☞ are responsible for coordinating activities, consolidating plans and reports of woredas and relaying requests from regional water bureaus and/or Woreda water offices,
- ☞ Zonal Water Offices are the links between Regional Bureaus and Woreda Water Offices

7.5.4 Woreda Cabinet

The Woreda Cabinet effectively functions as the Woreda WaSH steering committee. Its main function is oversight and guidance of the Woreda WaSH program. In this specific O&M framework, its responsibilities include but not limited to:

Box 7-7 presents the Roles and Responsibilities of Woreda Cabinet in O&M management.

Box 7-8: Roles and Responsibilities of Woreda Cabinet

- defining O&M priorities and objectives for the Woreda
- establishing the Woreda O&M Team
- approving O&M annual plans and budgets
- confirming community contribution transfer arrangements with Woreda Finance Office or local Micro Finance Institution
- receiving, approving and forwarding O&M monitoring reports
- conducts regular performance review of the WWT and its member offices and the O&M implementation in the Woreda
- advocates the O&M finance requirements to sustain utilization of the schemes
- ensures that the O&M annual plan and budget is approved by the Woreda Council

7.5.5 Woreda Water Offices

Box 7-9-8 presents the Roles and Responsibilities of Woreda Water Office

Box 7-10: Roles and Responsibilities of Woreda Water Office

- The Office shall prepare the O&M annual action plan, budget and identification of spare part supply requirement for maintenance within the Woreda and submit to the Zone Water Office.
- The office shall facilitate the implementation the O&MM procedure
- The office shall support the establishment of tariff collection pattern and follow up the tariff collection and the saving.
- The office shall ensure that WASHCOs have all the necessary tools and documents for O&M.
- The office shall provide new and refresher trainings to pump attendants and care takers in collaboration with the Region and Zone.
- The office shall ensure that trained artisans exist in the Woredas for the maintenance of rural water supply schemes.
- The office shall ensure the availability of the most needed spare parts in the Woreda for sell to the user communities.
- The office shall facilitate the maintenance of water points through pump attendants/caretakers/artisans.

- The office shall be responsible for the development of technical capacity in the maintenance of schemes at Woreda level. It will also periodically provide training to concerned people at Woreda, kebele and WASHCO level as their regular task.
- The office shall maintain defects, which are beyond the capacity of pump attendants, care takers and artisans.
- The office shall take data on the number of users of each scheme.
- The office categorizes water user communities as category 1 and 2 to facilitate the proposed demonstration in the implementation strategy of the procedure.
- The office will keep records of O&M status of all water supply schemes in the Woreda and updated annually.
- The office monitors and ensures the regional performance indicators for O&M are implemented.
- monitors the water quality status of rural water supply schemes at least twice a year and undertakes disinfection.
- The office shall report to the Zone Water Office and to the Regional water Bureau's on monthly basis.
- The office shall prepare the annual spare parts and associated items needs, calculate the budget required and presents it to the Zone Water Office for budget allocation.

7.5.6 The Roles and Responsibility of Beneficiary Community

Table 7-4 below describes the roles and responsibilities of the users' community to ensure the sustainability of the schemes.

Table 7-4: Roles and responsibilities of beneficiary community

Roles	Responsibilities
☞ To get the service without any discrimination. ☞ To be elected for or elect the water supply and sanitation committee. ☞ To elect caretaker for the scheme and fix the salary. ☞ To decide on the type of tariff rate and the amount to cover running and maintenance cost and the like. ☞ To select the site of the water source	☞ To use the water scheme properly. ☞ To safe guard the scheme from damage or abuse. ☞ To be involved actively in every activity that shall be significant and required for the scheme, e.g. construction of access road, clearing the surrounding areas of water source and water point. ☞ To attend the general meeting that shall be arranged by the committee. ☞ To pay on time users fee that shall be

Roles	Responsibilities
and the water point. ☞ To decide upon the expansion and choice of technology. ☞ To decide upon the type and amount of contribution whenever the need arises. ☞ To fix the amount of allowance for the water committee member. ☞ To attend the general meeting. ☞ To decide on free services provision of water for individuals who are not capable to pay for the service. ☞ To decide the type and the amount of incentive that shall be given for the committee members.	decided on the general meeting. ☞ To report on time any break down or unusual conditions of the scheme to the concerned body. ☞ To safe guard the water source from pollution and keep the scheme under good sanitation condition. ☞ To co-operate with the water supply, sanitation and hygiene committee and caretakers. ☞ To perform every activity but only significant for the scheme that shall be assigned by the committee chairperson, for instance conveying message to the concerned bodies. ☞ To adhere to the regulation set to manage the scheme.

7.6 Asset Transformation

Asset transfer is a shift in management and/or ownership of RPS system, from the one who financed construction, (most commonly WRB and NGOs), to WASHCO/ WUB. Community ownership and management of assets is not new. It has a well-documented history going back hundreds of years. In recent years, the momentum behind community asset transfer in RPS has gathered pace with increasing recognition of the contribution it can make to the development of a community management and ownership. Before handing over the schemes to WASHCO/WUB the following points should be considered.

- Commissioning and testing of water supply facility,
- Facilitate official handing over procedure in the presence of concerned stakeholders,
- List all water supply facilities,
- Availed the total cost of construction,
- Prepare business plan and conduct tariff study,
- Conduct adequate training for WASHCO/WUB on O&M,
- Provide necessary maintenance tools and spare part for fast moving Items,
- Provide seed money for Employment of Operators and Fuel in case the system operated with diesel generator,
- Trainee Operators and care taker,
- Provide built up drawings and operation manuals.

7.7 Conflict Management and Resolution

In some of your communities you will run into conflict e.g. conflicts between leaders or groups within the community or strong disagreement on issues. Conflict arises in utilization common water sources for different purpose (water supply, irrigation and other uses). There is nothing wrong with conflicts. But they should be solved. If you ignore them, they may bring more problems.

7.7.1 What can you do?

Avoid conflicts that are not related to your work - e.g. conflict between political parties. Ask the District Councillor or another neutral person to help deal with this type of problem.

Help solve conflicts related to your work. For example the community may disagree on how to collect money or where to site a new facility. To deal with these conflicts, you should:

- **Recognise that there is a problem.** Don't ignore it or tell people there is no problem. Acknowledge it.
- **State both sides of the argument** and invite speakers to talk for each.
- If people are not listening to the other side of the argument, ask each side to **summarize the other's argument**.
- **Get people to look at the strengths and weaknesses of each position** and come to an agreement. Try to create a situation where there is no loser!
- **Summarize** and ask for decision.

7.7.2 How do you work as a TEAM?

- You will work as a team. Each person should have a role in running the meetings.
- Discuss this before you go to the community.

Take turns in the lead role - let one team member start, then after a while have another team member take over.

When you are not facilitating, **observe** the process and **document** what is said. You may see things that the lead facilitator cannot see because s/he is in the heart of the action. Listen carefully so you can take over without repeating what has already been said.

Take over at appropriate points –

- Help facilitator when s/he gets stuck about where to take the discussion.
- Suggest a new question - or encourage shy people to contribute.
- Provide a summary that helps people see what they have said.

Give a signal to the main facilitator if you want to help out.

Step in and take over by asking a question.

Don't break the discussion by getting into a long talk with lead facilitator.

At the end of the meeting sit together as a team and review what happened:

- How was the level of participation? Who talked? Who didn't talk?
- How were the issues handled? Did you cover all you needed to cover?
- What issues came up which will need attention in the next meeting?
- How can you improve your facilitation at the next meeting?

Annexes

Annex S: References

A Situational Assessment of Addressing Non-Functionality of Rural Water Supply in Tigray Region, *Demewoz Consultancy*, April, 2014.

A Situation Assessment on Existing Operation and Maintenance Management for Rural Pipe System and Pastoral Areas Water Supply Facilities, COWASH, *Demewoz Consultancy*, May 19, 2014.

Assessment of existing Point Water Sources Operation and Maintenance situations, COWASH, *Demewoz Consultancy*, May, 2013.

Douglas Ng'ambi (November, 1991),. A Manual on Operation and Maintenance of Communal Stand post for Extension Workers and Caretakers, Piped Supplies for Small Communities (PSSC) Project Zambia,

Harold Lockwood and Stef Smits (2011), Supporting Rural Water Supply, Moving towards a Service Delivery Approach, IRC International Water and Sanitation Centre and Agua consult.

Ministry of Water Resources, (June 2000) *Ethiopian Water Resources Management Policy*, Addis Ababa

Jan Davis and François Brikké (1995) *Making your water supply work, Operation and Maintenance of small water supply systems, IRC, The Netherlands.*

Annex T: Sample By-Law for WASHCO

The following table indicates the minimum contents of By-Law for WaSHCO's

By-Law for Water Users Association

Considering the need of appropriate organization organ to take care of the overall water supply management of our community on water scheme in sustainable manner and promote improved hygiene and sanitation practices, **Water Supply Users Association** has been formed by the beneficiaries of the water scheme of _____ in accordance with the regulations and rules stated below.

Article -1: Name

The name of association shall be _____Water Supply Users Association; hereafter called "the Association".

Article – 2: Address

The office of the Association shall be in _____

Article – 3: Objectives

1. Ensure sustainable operation and maintenance of Community's water scheme.
2. Promote improved hygiene and sanitation practices in the community
3. Ensure direct participation of the water users in the water supply management of the community's water scheme
4. Set water tariff
5. Assign appropriate water scheme operator (care taker)
6. Carry out other activities that promote sustainable operation and maintenance of community's water scheme and improved hygiene and sanitation practices.

Article – 4: Source of Income

The following shall constitute the source of income of the WASHCO:

1. Water tariff being collected from the beneficiaries
2. Subsidy and donations that might be extended to the WASHCO

Article – 5: Membership

1. Any person residing in the user community can join the WASHCO on voluntarily basis.
2. The membership shall be valid after being signatory of this by-law

Article 6 Right and Obligations of the members

6.1 Rights

1. Use the water facility of the community
2. Elect and be elected in WASHCO
3. Participate in General Assembly and cast their ballot

6.2. Obligations

1. Abide by the By-law of the WASHCO
2. Pay for the water supply service according to the tariff set by the WASHCO
3. Participate directly in the operation and maintenance of the community's water scheme

Article – 7: Failure to meet membership obligations

A member who fails in fulfilling his/her obligations shall be deprived the right of the Association's membership.

Article – 8: Organizational Management of the Association

The Association shall have the following organizational management arrangements:

1 General Assembly

2 Water, Sanitation and Hygiene Committee (WASHCO)

Article – 9: The General Assembly

The General Assembly is comprised of all members of the Water Supply Users Association and shall discharge the following responsibilities:

1. Elect the members of the WASHCO
2. Define and determine their duties and term of service
3. Make decisions on critical issues of the Association.

Article -10: Water, Sanitation and Hygiene Committee (WASHCO)

The WASHCO shall comprise of 5-10 members, at least half of the members must be women. The core members of WASHCO are Chairperson, Secretary, Cashier (Treasurer), Store Keeper and Inspector.

The committee shall have the following powers and responsibilities

1. Implement the decisions passed by the General assembly
2. Execute the operation and maintenance of the community's water scheme
3. Ensure the proper utilizations of Association financial and material resources
4. Suspend the membership of users who fail to meet their obligations.
5. Maintain partnership with stakeholders on sustainable operation and maintenance of community's water scheme and on promotion of improved hygiene and sanitation practices.

Article -11: Duties and Responsibilities of WASHCO members

11.1: Chairperson

- Provide leadership to the overall WASHCO activities
- Approve payments
- Supervise the activities of the cashier
- Order purchase of spare parts
- Ensure the collection water tariff and other incomes
- Arrange services for maintenance in consultation with WWO.
- Facilitate the proceeding of general assembly of the community
- Hold regular WASHCO meeting as well as ad-hoc meeting when necessity arises
- Attend meetings at Woreda or Regional levels representing the WASHCO.
- Make official communication with public institutions, NGOs and private firms representing the WASHCO.

11.2: Secretary

- Prepare the minutes of meetings of the general assembly as well as of regular and ad-hoc WASHCO meetings
- Perform all activities of the chairperson in his/her absence.
- Prepare receipts for collection of incomes
- Prepare payments and submit for approval of the chairperson
- Record all incomes and expenses in account book
- Make sure that collection of incomes and effect of payments shall be made only by cashier.
- Prepare quarterly report on financial and other activities of WASHCO for approval of the chairperson
- Keep all financial and administrative records of WASHCO properly
- If the deposit of the WASHCO is at bank or approved institution by General Assembly, he/she will be co-signatory with chairperson and cashier.
- In case of cash payment, he/she will be co-signatory with chairperson.
- Prepare, contract agreements with service providers

11.3: Cashier (Treasurer)

- Collect incomes based on the receipts prepared by the secretary
- Effect payments in accordance with approved documents, by chairperson and secretary.
- Keep the deposit slips bank or approved institution of for record.
- Request petty cash for immediate expenses for operation and management of the water scheme, the amount shall be fixed by the general assembly.
- Should keep all the documents at hand properly for inspection and auditing.

11.4: Store Keeper

- Keep the properties of the water facility by registering by the format prepared by Woreda Water Office.
- Issue items upon the approval of the chairperson and the secretary.
- Prepare report on the status of fast moving items for replacement and purchase.
- Keep all records in proper for inspection and inventory.

11.5 Inspector

- Inspect the financial management of WASHCO.
- Supervise the proper utilization of purchased items
- Check the monthly water consumption and respective income.
- Ensure the expenses of WASHCO are following acceptable procedure and regulations.
- Act as internal auditor
- Inspect the records of the Secretary and the cashier.
- Prepare report on the overall water supply management of the water facility.
- Present the report to the general assembly of the beneficiaries.
- **Article -12: Cautions and Penalty**
- **12.1. Cautions and Penalty for Individual WSUA member**
- The performance of water scheme shall be monitored by WASHCO under the supervision and guidance of Woreda Water Office.
- If, in the opinion of WASHCO, any user household shows that individual household is unable to discharge duties set in the By-Law due to the following reasons, WASHCO reserves the right to withdraw the usufruct right from individual user of the household:
- (i) failure in regular payment of water fees consecutively three times against advises and warning to be made by WASHCO; and,
- (ii) Unclearness or dishonesty is observed to abide by the By-Law.

In the case of failure in regular payment of water fees consecutively three times, the representative of the individual household is advised to pay penalty to WASHCO at the rate of Birr _____ or by any other equivalent form of penalty as _____.

In the case of unclearness and dishonesty practices, the representative of the individual household is requested to make compensation by an action set as _____.

12.2 Cautions and Penalty for WASHCO and WSUA

The performance of WSUA as well as WASHCO is monitored by Woreda Water Office.

If, in the opinion of Woreda Water Office, WSUA and/or WASHCO shows that WSUA and/or WASHCO is unable to discharge duties set in the By-Law due to the following reasons, Woreda Water Office reserves the right to withdraw the usufruct right from WSUA:

(i) Improper use of water scheme out of the scope of the set work; and,

(ii) Unclearness or dishonesty is observed in keeping rules and regulations set in the By-Law.

The WSUA/WASHCO shall not transfer water scheme and related equipment and materials to any other individuals or organizations in all cases. In such case, the water scheme and related materials should be compensated by WSUA and the WASHCO.

Solar and Wind Energy

Pastoral Area Water Supply

(Parts E, F, G, H)

Solar and Wind Energy, Community and Financial Management of the Pastoral Areas

PART – H: FINANCIAL MANAGEMENT IN PASTORAL AREAS

Document 10

PART – H: FINANCIAL MANAGEMENT IN PASTORAL AREAS

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Definition of Financial Terms

Terms	Definition
Budget	A summary of the expected income and expenditure associated with a particular activity
Fixed cost	These are costs that are not related to how much water the WASHCO/EWB produces
Recurrent cost	These are costs that are dependent to how much water the WAO/WUA produces.
Variable cost	Same as recurrent cost
Operating Cost	Costs incurred in the operation of the WASHCO/EWB
Revenue	Income to the WASHCO/EWB
Capital cost	Cost incurred for something that has a life span that extends over several years
Operating Balance	Revenue less operating costs (fixed and recurrent costs)
Operating ratio	Revenue divided by operating costs.
Capital replacement	Describes a situation in which the revenues are sufficient to cover costs of replacing the assets

8. FINANCIAL MANAGEMENT

8.1 General

The financial management such as recording of income and expenditure, internal auditing has to be conducted regularly. Thus, failure to keep appropriate financial records resulted with inability to cover/ at least costs of operation, maintenance and common repairs.

Setting water tariff should depend on the analysis of willingness and ability to pay, choice of technology, cost effective design and complexity of the scheme through. Communities that do not have easy access to water are generally willing to pay for improved water supply, regardless of their ability to pay.

Thus, National Water Resource Management Policy advocates community participation in all phase of the project and water as social and economic goods even if it was not fully implemented mainly due to lack of awareness.

Tariff setting for rural water supply is one way of mobilizing resources from communities. All national and regional governments praise this kind of community involvement as far as they put issue of charges beneficiaries should pay for services. However, money generated from sell of water and services financial management and reporting system that is operated by Water Boards or WASHCOs should transparently enter into the reporting lines, frequency, timeliness and format (different charts of accounts for different water supply schemes).

Financial Management involving community participations pave attention for the following points.

- Partnership and negotiations for full or partial cost recovery,
- WASHCO/EWB and role and tasks of main actors, with gender specific roles,
- Affordability and willingness to pay,
- Benefit cost analysis,
- Budgeting for costs, before, during and after construction: Cost sharing creating a budget: estimation of O&M costs,
- Choosing the type of financing system: Tariff setting, vending, community fund raising, credit schemes and revolving funds periodically, revenue collection system and flow of collected funds, establishing a payment system with the village,
- Administration of funds registration of collection funds and payments, bookkeeping, opening and using an account use of, funds for other sectors activities, money plan control and reporting to the community, sanctions for non payments, remuneration of water committee staff, and,
- Management Capacity: Decisions making process, problem solving capacity (in case of unexpected expenses or high inflation), information needed in order to make financial decisions, self monitoring, learning from experience, training needs, relationship with other actors.

To conclude user contribution for the water they consume is important for enhancing financial sustainability of the scheme. Transparent sound financial management that supported with regular auditing can enhance financial sustainability and meet Ethiopian Water Resource Management Policy requirement for covering at least O&M cost.

8.2 Water Resources Management Policy

The Ministry of Water Resources has issued the Water Resources Management Policy (WRMP) in 1999. The WRMP has considered water as social and economic goods. The principle of cost recovery, decentralized management, sustainability of water supply and capacity building, research and development are incorporated as the most important concepts in the water policy.

It creates and promotes a sense of ownership of water supply schemes by the communities. It charges the communities as their responsibility to operate and maintain water supply systems; and develops participatory management practices. The policy enhances principle of financing the operation and maintenance of rural water supply schemes by the communities.

A few highlights of Water Policy relating to Water Supply and Sanitation particularly on relation to financial management are:

- The setting of the tariffs to be **site specific**; ensure that rural tariff settings are based on the objective of recovering operation and maintenance costs, Establish a **"Social Tariff"** that enables poor communities to cover operation and maintenance costs. Develop flat rate tariffs for communal services like hand pumps and public stand posts,

- The rural communities, to cover at least the operation and maintenance costs of water schemes while the urban cover the full cost recovery,

- Promote objective oriented training with special emphasis on trades-level training, community participation, administration and finance, and operation and maintenance,

- Involve NGOs in funding and in the actual implementation, operation and maintenance of WSS projects (strategy says).

8.3 Preparing Annual Budget

Preparation of an annual operating budget is the first step WASHCOs or Executive Water Boards must take to ensure that there is an accountable and transparent financial management system in place and that the WASHCOs or Executive Water Boards (EWBs) operates on a financial sustainable basis. There are various reasons why a budget is important:

1. An annual budget, prepared by the WASHCO, is submitted to the Woreda or Zone Water Office and subsequently to the membership for approval. If the system is managed by the Executive Water Board like as RPS, the Water Administration Office Management prepare and submit the EWB through the Manager, and then the EWB submit either to the Woreda or Zone or Regional Water Bureaus as per the accountability hierarchy.

2. Preparation of an annual budget requires information regarding expected income collected from the community and expenditure to run the water supply schemes, and requires planning for O&M costs.

3. Expenditure should be kept within the approved budget according to each budget line.

A budget helps to enhance transparency and accountability, quality of works, service provision and efficiency and effectiveness.

8.3.1 Components of Budget

A budget has two major components – revenue (income), and expenditure – fixed costs and recurrent costs:

a. **Revenues** consists of:

- Money expected to come in during the year from different sources like payments of the water bills, tree seedlings sales, and any other revenues.

b. **Costs** consist of:

- All expenses/items that the WASHCO/EWB will need to spend money on during the year in order to carry out its normal business. These include cost of fuel for the pump, cost of spare parts, workman's fees, office rent, committee allowances, unexpected breakdowns, etc.

8.3.2 Types of Budget

8.3.2.1. Operation and Maintenance Budget

The O&M cost is the total estimated cost required to manage, operate and maintain the water supply system. The projection of the O&M Budget usually is fairly straightforward, unless major deteriorations of the facilities have created expectations of unpredictable cost levels, or serious local or global events are expected to cause large spikes in the prices of some essential supplies. Otherwise, it is projected from the results of past operations and adjusted to fit the current or projected prices and costs.

(i) Nature of O&M Costs

It is important to realize that in a well-managed water supply service office; there are only two major groups of expenditures:

1. **Capital Outlay/Investment:** the costs of which are determined at the initial stages of the business, or when it expands, upgrades, or replaces the physical facilities for water supply. The annual costs are then composed of the depreciation of the major facilities, the financial costs incurred in their acquisition and installation, and actual CapEx disbursements during the year.

2. **Operation and Maintenance:** which involves practically all the activities of the business whose, focus is basically to employ its physical facilities to distribute the water 24/7, reliably and efficiently, and to ensure that these physical facilities remain capable of continuing to distribute the water 24/7, reliably and efficiently.

From this, it will be clear that the O&M cost is one of the two major components considered in determining the initial water tariff of the system and the necessary adjustments in tariff that may be dictated by external factors and as the system expands in the succeeding years of operation.

(ii) Revenues needed to support O&M Costs

From the foregoing discussion, it becomes very clear also that WASHCO/EWBs need to collect water revenues continually and promptly in order to reliably operate and maintain the water supply facilities. In too many instances, insufficiency of funds is at the root of poor system maintenance.

(iii) Need to educate Users

Each member user should be made to realize the importance of a well-supported O&M on the reliability of their water system. They should be educated on what the O&M budget comprises and why a collection is made for the water supply O&M. The training should be offer during the election of General Assembly and Board.

(iv) O&M Costs Items

Following is a list and description of what are generally included as O&M cost items:

1. Salary/wages refers to the gross personal services expenses;

2. Power costs and related expenses refer to the total electricity and fuel, oil, and lubricants incurred in the operation;

3. Chemical cost for water treatment like Chlorine, Aluminum Sulfate if applied which also include laboratory chemicals and equipment; if any,

4. Maintenance expenses refer to the repairs and maintenance costs of facilities, exclusive of salaries for operators and staff who undertook the repairs and maintenance;

5. Permits/Regulatory fees are expenses incurred in obtaining or updating business permits, licenses and payments for regulatory fees;

6. Board costs are expenses incurred during Board meetings as well as board per diems, if any;

7. Operation CapEx are disbursements made which do not enhance the physical distribution system but are necessary in improving the office environment, work efficiency, or security, examples of which are fax equipment, light fixtures, housekeeping equipment, vault and filing cabinets, and computers;

8. Miscellaneous costs refer to other maintenance and operating expenses like representation expenses excluding depreciation, interest and other bank charges. Capital Expenditure (CapEex) Budget.

   The annual CapEx budget summarizes the cost of the projects that the WAO/WASHCO will implement during the budget year. These are cost items that involve large amounts, like pipelines, reservoir, connections, source development, major repairs or expansion of the network. The amount is determined based on the project plans and the estimates of their cost.

8.3.3 Budget Monitoring and Control

The Woreda Water Offices must monitor in regular interval of the WASHCO/Executive Water Board Management on the level of expenditures against the budget on a monthly basis in order to control overruns that could lead to unexpected fund shortfalls. In turn the Executive Water Board Management must monitor the Water Administration Service Office.

Monitoring the budgeted expenditures enables management to take cost reduction measures, make decisions on budget realignments, and consider the need for a supplemental budget if it is forecast that the approved budget for essential expenditures will be exceeded.

8.4 Sources of Income

8.4.1 General

This section looks at financial aspects of water scheme management, which is an essential part of sustainable O & M and management of water scheme with regardless of type of water scheme.

In the community-based water scheme management, **Cost Sharing for O & M of a water scheme** is an important government policy. The community needs to pay for maintenance & repair of the water schemes and save the replacement of the equipment.

Maintenance is your job! When a part wears out, you have to buy a new part. When the facility breaks down, you have to fix it themselves or pay service provider to fix it.

To take measures promptly when the water scheme gets broken down, you need to **collect money in advance.** With enough financial resource, you can buy spare parts and pay for a repair works and other necessary expenses. Some of this money should be used to buy spare parts in advance.

Before starting concrete financial management tasks, you need to understand about the O & M cost and how to cover O & M cost.

4.1.1 Source of Income Category

- User fee which shall be paid to cover the project cost or running and maintenance cost every week / two weeks /month / year in the form of cash and/or kind.
- Volunteer contribution from beneficiary community or outsiders in the form of cash and/or kind.
- The committee shall arrange fund raising activity to collect money. In this case different systems for special contribution shall be arranged including labour and locally available material that could be converted to money.
- Support of money from government and non-government organization in cases of a considerable problem encountered to run the activity.
- Revolving fund for spare parts which shall be availed from donor or government agencies.

8.4.2 Users Fee Payment Condition

- Every beneficiary household except those who shall be exempted from payment pay Birr____ every week/ two weeks/ month/year. The amount to be paid shall be prepared by the Committee and endorsed by the benefiting community in the General assembly.

- Payment in accordance with the agreed tariff ,

- The payment shall be effected to the cashier, water point attendant or bill collectors.

8.4.3 O&M Cost Sharing

The cost of running this service should be shared between the user community and the Woreda (through an annual allocation from the regional level). The Maintenance Support System will need to demonstrate value for money to justify this cost to the user communities.

- Communities should contribute a part of the capital cost of water supplies, but should bear the total cost for operation and maintenance, and a part of the cost of the maintenance support service.

- Strengthen community O&M financial management systems to ensure accountability and enhance transparency regarding the flow and use of Government and partners' funds at all levels.

- The contribution by the community mainly for running and maintenance costs for point water sources like hand dug well, shallow wells fitted with hand pumps as well as on-spot spring development.

- The Ministry of Water, Irrigation and Energy develops the cost-sharing guideline, while the Regional Water Bureaus, Zone and Woreda Water Offices determine the exact contributions to the capital cost and the maintenance support service, according to local economic conditions. Nevertheless this strategic framework recommends the following cost sharing:

The costs of maintenance of water supply facilities shall be borne primarily by the users. They will meet costs pertaining to:

(i) Repair and replacements of worn out parts;

(ii) Labour costs of O&M (caretakers, scheme attendants, handpump mechanics, etc);

(iii) Administrative/ logistical requirements; stationary, public transport, fuel, per-diem etc,

Cost sharing between government and communities may involve on the following issues but it depends on the local situation.

(i) Replacement of hand pumps,

(ii) Provision of spare parts which price is beyond the affordability of the community,

(iii) Fuel cost for those community get water supply from motorized schemes but do not have electricity.

The community may require external support from governments or NGOs to meet those costs beyond their ability. These may include;

(i) Borehole rehabilitation to include:

- Desilting of borehole,
- Fishing of dropped handpump parts (pipes and rods), and
- Replacement of whole riser pipe.

(ii) Electro-mechanical maintenance and replacement

- Maintenance and replacement of pumps (surface and submersible), generators, and switch board.

(iii) Major extensions of piped systems (RPS) if support requires;

(iv) Refresher and regular trainings for WASHCOs, caretakers and technicians; and

(v) Monitoring and technical support.

Eventually when the life standard and income of the community increase and ensured the affordability, the support can be terminated and the cost of all O&M incur will be the responsibility of the community themselves.

8.4.4 Ability and Willingness to Pay

With regard to income related issues, detailed up-to-date information regarding specific income data of aforementioned beneficiary should be collected using structured household survey for sample households 30 – 50. However, experiences show that people are usually unwilling to reveal their periodic income.

Affordability deals with the analysis of ability of consumers to pay for water. In order to analyze the ability of consumers to pay for water, the water supply consumption of the users and the income level of consumers (Low-income section of the society) should be identified and computed. Specially, the ability of the very poor households in the area shall be focused upon.

For reasons of practicality, **Affordable Price** is defined as maximum amount, which a household can pay for water without greatly compromising its ability to buy other basic goods and services for its members.

Therefore, affordability can be expressed as a **fraction or percentage** of the household income. Based on the accepted practice of institutions, which is derived from analysis of domestic expenditure behaviour in Ethiopia, up to 5% of household's income is assumed affordable for water. It is advisable if calculation made for affordability adopts this assumption.

The rational for conducting studies of affordability of water tariffs evolves from two basic considerations:

- The Ethiopia Water Resource Management Policy recognizes water as a commodity with not only economic value but also a social value. Therefore providing affordable water supply to the rural population is one of the major objectives of the policy. It is of

paramount importance to make sure water price does not limit the access to potable water by the poor.

- The other important consideration is that Price of water that is not affordable by the majority of the intended beneficiaries makes the water supply system financially unsustainable.

a) For low* consuming *Yard Connections (5 m^3***/ month)***

Assuming that the monthly average income of this group is X Birr/household and applying affordability criteria of 5% of income, the maximum this group is able to spend on water is x Birr per month per household. This includes monthly meter fee of X Birr.

Assuming household size 5 and the average per capita consumption will nearly increase from the existing 15 l/d to 20 l/d due to the intended improvement of the scheme, the average domestic consumption would become:

20 l/c/d * 5 persons * 30 days = 3 m^3 per month/household

Tariff affordable = x Birr/3 m^3 = X Birr /m^3

Consequently, the maximum tariff that would be affordable by the low-income households that consume only up to 3m^3 is X Birr per m^3 of water consumed.

b) For Public Fountains (PF)

The average income of this household group is assumed X Birr per month/household. (Household using water-vendors, as their primary or secondary sources of water, are included in this category).

- Ability to spend on water is 15 Birr per month/ household (5% of X Birr).
- It is assumed that the average per capita consumption would rise to 20 l/c/d from the existing with the improvement of the system, the average domestic consumption would become:
- 20 l/c/d * 5 persons * 30 days = 3.00 m^3 per month/household
- Tariff affordable = x Birr/3.m^3 = x Birr/m^3

Consequently, the maximum tariff that would be affordable by PF user is X Birr/m^3 of water consumed. Therefore, affordable tariff cannot be exaggerated.

Besides, willingness to pay has to be assured as it is more important in predicting success than affordability to pay. Many communities who are able to pay have not in fact been able to raise the cash, while some poorer communities who are less able to pay have successfully financed their systems.

The primary incentive that makes communities willing to pay seems to be guaranteed access to an adequate supply of water to communities that do not have easy access to inadequate supply of water. Communities that do not have easy access to water are generally willing to pay for improved water supply, regardless of their ability to pay. Contrary to this, there are communities who are reluctant to pay for the service as they have alternative water source relatively easy to collect.

8.5 Determining Expenditures

8.5.1 Identifying operation and maintenance costs

Box 8-1 below presents the costs of O&M of water supply facilities.

Box 8-1: Operation and Maintenance costs include:

- **Material costs –** consumables, chemicals, energy, tools, spare parts and equipment
- **Works personnel -** staff involved in operation, maintenance, routine preventive maintenance, repairs, and construction for minor rehabilitation
- **Management personnel -** staff involved in planning, supervision, financial management, administration, and monitoring
- **Financial costs** - interest, amortization, depreciation, exchange rate variations, inflation
- **Environmental costs -** water source protection and conservation,
- **Support costs –** training support, technical assistance, institutional strengthening, monitoring and evaluation
- **Future investment costs** - Major overhauls (rehabilitation), replacement, and extension
- **Other costs –** transport, services paid to a private contractor, unaccounted for water due to leakage, bad administration and vandalism

All the above types of O&M cost should be considered in calculating and setting of tariff.

8.5.2 What is O & M Cost?

The scope of the cost recovery for a water scheme includes three groupings of cost;

i. Running (operation) cost

ii. Maintenance cost

iii. Replacement cost

For the purpose of simple explanation, the case of a hand pump, which is one of major water schemes, is shown as an example.

(1) Running Cost

Running cost, which is also called as **operation cost**, can be defined as cost required for day-to-day operation of a water scheme. Such operation cost includes in general the following items.

- Personnel expenses (salary for a pump attendant or guard)
- Overhead cost (travelling cost, communication, per-diem etc.)
- Office expenses (stationeries, etc.)

Example:
A WASHCO in XXXX Kebele employs one pump guard. Monthly running costs of XXXX WASHCO are as follows:

Item No.:	Description of Expense	Amount (Birr)
1	Salary of pump operator (Ato XXXXXX):	150.00
2	Stationary expenses:	30.00
3	Per-diem for travelling to Woreda	50.00
	Total	230.00

(2) Maintenance Cost

Maintenance cost is concerned about any cost required for continuity of operation of a water scheme without any breaks including spare parts cost, repair cost, technical service fee, and so on.

With regard to the regular replacement of spare parts for Afridev hand pump, it is recommended to follow a schedule below. Some parts (U-seal and bearings) need to be replaced every 6 months, others once a year, and others once a two years.

Normally a community would put aside enough money to cover the FAST WEARING PARTS - parts that need to be replaced frequently. In addition, WASHCO should buy a few long wearing parts – e.g. rod) - as a way of investing the money and guarding against inflation.

Table 8.1: Suggested Schedule of Spare Part Replacement

Part	Months					
	6	12	18	24	30	36
U-seal	√	√	√	√	√	√
O-ring (big)		√		√		√
O-ring (small)		√		√		√
Bobbin		√		√		√
Rod Centralizer		√		√		√
Bearing (inner)	√	√	√	√	√	√
Bearing (outer)	√	√	√	√	√	√
Hanger Pin						
Fulcrum Pin				√		
Pipe Centralizer				√		

On average most pumps will require the following maintenance:

YEAR 1: No major problems - the warranty will cover any costs during first year.

YEARS 2-4: Replacement of fast-wearing parts - but no major repairs.

YEARS 5+: Major faults will occur, which require help from the Woreda Water Office.

(3) Replacement Cost

The replacement cost includes an amount necessary to replace of equipment at the end of its service period. A service period of a hand pump lasts for 10 years under normal handling.

Conceptually somebody should accumulate financial resources to procure a new hand pump in assumption that the present pump shall cease to function forever after 10 years. In other words, depreciation cost should be covered including water fees.

These above three types of cost are needed to be covered through regular payment of water fees for only one single purpose. The purpose is to produce potable water for drinking continually.

How and who bear those costs? Let's look at the following sub-section.

8.5.3 Community- based Cost Recovery

8.5.3.1. Recovery of O&M costs only, with initial use of subsidies

This consists of introducing progressively an "O&M costs recovery only", mainly by subsidizing costs (for example the price of spare parts, M&E cost, the cost of fuel) at the beginning, and providing free technical support for some maintenance. Although this approach can be necessary for poor communities, the use of subsidies can send wrong signals to a market, especially for spare parts. Some arrangement will need to be made about who will recover the other costs that the community will not cover, and how.

(1) Basic Concept of Cost Recovery

You (community) need to build up a maintenance fund so that you can spend money to buy parts and make repairs whenever necessary.

As you have seen the basic formula below, which you have to save is as below

Total Cost = (1) Running Cost + (2) Maintenance Cost + (3) Replacement cost

The Total Cost is **Supported by Users** of the water scheme !

Question: **How do Users support the Total Cost?** That is revenue, mainly water tariff paid by users.

Revenue = Tariff x Quantity

(2) Some idea on the cost to be borne: How much do we need to save?

Based on an extensive study conducted in Ethiopia, a required amount of maintenance cost is estimated to account for 5 % of total replacement cost annually. In this manual, cost of a hand-pump is considered. We shall use an example of average cost of a hand pump at Birr 8,000.00 for this paper.

Example:

Total replacement cost: Birr 8,000.00

Annual Maintenance cost: Birr 8,000 x 5 % = Birr 400.00

Monthly Maintenance cost: Birr 400 / 12 months = Birr 33.30

Taking an estimated price of a hand pump at Birr 8,000, a WASHCO accumulate at least Birr 800.00 annually, while this can be interpreted as monthly reserve with an amount of Birr 66.00.

Example:

Cost of a hand pump: Birr 8,000.00

Service period: 10 years

Annual Replacement Reserve: Birr 8,000/10 = Birr 800.00

Monthly Replacement Reserve: Birr 800 / 12 months = Birr 66.00

Note: The above calculation is prepared without any considerations on interest rate, inflation rate, and foreign currency exchange rate.

8.5.4 Water Supply Tariff

A water tariff is the rate at which users are charged for water. If cost recovery aims to satisfy an increasing demand for water then the tariff should reflect the cost of the operation and maintenance for rural schemes as stipulated in Water Resources Policy. However, many water supply tariffs do not achieve coverage of the current costs of O&M.

The discussion is moved into water tariff. O&M cost recovery shall be taken into considerations under the subsequent exercises.

Let us refer to the following basic formula in the cost recovery.

Total Cost = (1) Running Cost + (2) Maintenance Cost + (3) Replacement cost

a) Revenue:

Taking the above case of XXX WASHCO, let us calculate an amount of required revenue.

Revenue = Tariff x Quantity

Minimum required revenue accounts for the sum of running cost plus maintenance cost plus and replacement cost in reference with the above basic formula No. 2

Example:

Monthly running cost: Birr 230.00

Monthly maintenance cost: Birr 33.00

Monthly replacement cost: Birr 66.00

_____

Total Birr 329.00

The answer to an amount of required revenue shall be Birr 329.00

Then, let us move into a discussion on quantity required.

b) Quantity:

In accordance with technical standard, a hand pump lifts up waters with an amount of 0.2 liter per second. XXX WASHCO sets service hours separately in the morning and in the afternoon.

Example:

Service hours:

- Morning service (2 a.m. to 6 p.m.) local time: 4 hours
- Afternoon service (8 p.m. to 1 p.m.) 5 hours
- Hand pump operation hours (hours to lift up waters 8 hours)

(During 9 hours of service hours, it is estimated that a hand pump serves to lift up waters approximately for 8 hours)

- Pumping capacity (l/s): 0.2 litre per second
- Pumping capacity (l/h): 0.2 (l/s) x 3,600 (seconds) = 720 litre per hour
- Daily production of water (=Quantity): 720 l/h x 8 = 5,760 litre
- Daily Quantity in m^3: 5,760 / 1,000 = 5.76 m^3
- Monthly quantity in m^3: 5.76 x 30 (days) = 172.8 m^3

■ **Cross-check exercise:**

Is the above estimated quantity sufficient enough to serve for people's demand? Let us see as follows;

A hand pump is ideally set to serve 350 people (70 households).

15 liter per capita per day of water is required as set in the Universal Access Plan (UAP)

Therefore, a case of XXX WASHCO can be interpreted as follows.

Population served by a hand pump: 350 people from 70 households

Daily minimum demand: 15 liter per capita per day

Daily demand: 15 l/c/d x 350 = 5,250 liter

Therefore, the above estimation shall be considered as enough amounts to serve for 350 people in this case.

Tariff Rate:

Let us go back to the following basic formula.

By quoting the above case of XXXX Water Supply Users WASHCO, the required tariff can be calculated as follows;

Example:

Required amount of monthly revenue: Birr 329.00

Monthly amount of water production(quantity): 172.8 m^3

Required tariff: 329.00 / 172.80 = 1.90 Birr / m^3

Monthly consumption per household:

Daily consumption: 15 liter per person per day

Average size of a household: 5 people

Daily Household consumption: 15 l/c/d x 5 = 75 liter

Monthly household consumption:75 x 30 (days) = 2,250 liter

Monthly household consumption-2: 2,250 / 1,000 = 2.25 m^3

Monthly Water Tariff per household: 1.90 x 2.25 = Birr 4.30

Through the above simple exercise, it is suggested in the case of XXX WASHCO that each household shall be requested to make a monthly payment with an amount of Birr 4.30 in order to reach the O&M cost recovery.

8.5.4.1 Determining Revenue

It will be explained in the next section that as a manager of a drinking water supply system, the WASHCO and WUB most important job is managing the delivery of safe drinking water to the benefiting community. If the water supply system does not have the resources to cover the full cost of producing and delivering water, the system won't be sustainable. As a result the benefiting community will frustrate and may prefer to go to the unsafe traditional water sources.

Determining revenue helps in understanding the importance of recovering the full cost of running the system through water sale and how to structure the rates to achieve full recovery of O&M. Structuring the rates in this way will ensure that the WASHCO and WUB will have the financial resources to operate effectively and efficiently for the life time of the water supply scheme.

The following are the anticipated rate setting process:

Step – 1: Determine the full cost of O&M by calculating the listed cost items.

Step – 2: Determine the current revenues from water sale and others.

Step – 3: Consider the reserve requirements to ensure that there is enough finance to cover water supply scheme asset rehabilitation and repair costs

Step – 4: Determine the amount of money that should be collected from water sale through appropriate tariff to cover O&M costs and fully fund your reserve account.

Step – 5: Evaluate appropriate rate structures and design an appropriate rate as the case may be.

Step – 6: Implement the rates.

Step – 7: Review your rates and make changes when appropriate.

8.5.4.2 The objective in Water Tariff Setting

The objective of tariff setting is to raise sufficient revenue to meet the operational (and possibly capital replacement) costs in a way that is:

- Fair and equitable;
- Affordable (takes into account people's ability to pay);
- Justifiable (does not involve unreasonable profit or
- exaggerated costs);
- Easy to administer and control.

8.5.4.3 The objective in Water Tariff Setting

There are four main objectives embedded in the design of water supply tariffs: financial viability (or cost recovery), economic efficiency, equity and affordability.

- ***Cost Recovery:*** From the water service/operator's point of view, cost recovery is the main purpose of the tariff. Cost recovery requires that tariffs faced by consumers should produce revenue equal to the financial costs of supply. Moreover, the revenue

stream should be relatively stable and not cause cash flow or financing difficulties for the water administration office/Executive Water Board.

- ***Economic efficiency*:** Economic efficiency requires that prices be set to signal to consumers the financial, environmental, and other costs that their decisions to use water impose on the rest of the system and on the economy. Therefore, if economic efficiency is an objective the price of water should include not only the financial cost of public works undertaken but also the social (opportunity) cost of diverting water resources into public supply rather than using it for other purposes. In addition, water tariffs should be designed to discourage "excessive" uses of water, thus promoting water conservation as well.

- ***Equity:*** The term "equity" generally implies that the water tariff treats similar customers equally, and that customers in different situations are not treated the same. This usually means that users pay monthly water bills that are proportionate to the costs they impose on the utility by their water use.

- **Affordability:** Affordability implies that poor households are able to obtain adequate supplies of clean water. The terms "fairness," "poverty alleviation," and "affordability" are often used interchangeably to express this desire.

Additional objectives and considerations may also be involved in tariff design. For example, a tariff design should be easy to explain, understand, and implement. A tariff design should be acceptable both to the public and to political leaders.

8.5.4.4 Tariff-Setting Requirements

Tariff setting should NOT be done in a poorly considered, arbitrary manner. A deficient tariff level, once set, will be very difficult to remedy; and an excessive level would be unsustainable for the users, be subject to complaints, and tend to result in delays of payment and bad debts.

For this reason, the practice is for the water tariff to be fixed by the Water Board/WASHCO in consultation with the users, considering basically the capacity of the users to pay and costs of the O&M, as well as other relevant factors.

Tariff rates must satisfy the following requirements.

1. **Adequacy:** The revenues generated from a water rate schedule must be sufficient to meet the revenue requirements of the water supply service office. The rates should be able to promote the water supply service office's financial viability and growth.
2. **Public Service:** The tariffs must be set at a reasonable level that reflects the water supply service office's role as a public utility providing a public service.
3. **Equitable and Socialized Pricing:** The tariffs must equitably distribute the cost of the service to all classifications and sizes of connections. Their structure should define a relatively low fixed rate for some minimum level of consumption to benefit the low income users, and higher rates for those who use greater quantities of water.
4. **Affordability Level:** The rates must be kept affordable to the low income group (LIG). For this reason, the minimum charge for a ½" residential connection should, as a rule of thumb, not exceed 5% of the average income of the LIG within the service area.

5. **Water Conservation:** The rates must encourage the wide water usage needed to attain economies of scale, but must also discourage unreasonable and wasteful usage of water.
6. **Enforceability:** The rates must be fair, reasonable and transparent. They should be justifiable and acceptable to the consumers.

8.5.4.5 Basis for setting tariffs

Once the WASHCO/EWB members and committee members recognise the need to pay for the cost of operating and maintaining the water supply schemes, then the discussion can progress to how to set the tariff.

What should be the basis for setting the tariffs? Discussion on whether the tariff should be set according to one of the following criteria and what are the consequences of each:

1. What people can afford;
2. What people are willing to pay;
3. What the water supply schemes requires to cover the operating costs (partial cost recovery);
4. What the water supply schemes requires to cover all operating costs and to replace the assets when they need replacement (O&M cost recovery);
5. The maximum the water supply schemes can possibly charge.

The rural communities are generally willing to pay fair prices for good water Services and cover O&M costs as per the policy

8.5.4.6 Setting Your Rate

Now that you have organized your usage data, you may want to consider using the data to set rates. There are many ways to set rates; the option you choose should reflect the considerations discussed at the beginning of this step. The basic steps are the same for each approach: the revenue requirement is allocated to beneficiaries and then divided by the volume of water used by those beneficiaries. Under this study the proposed rate setting is using uniform rate.

First determine the average annual consumption. To determine the amount of annual water consumption multiplies the average monthly consumption by the number of months in a year i.e. twelve.

Secondly determine the short term revenue required to run the system using the worksheet prepared for this purpose.

The using the uniform rate the tariff form the meter cube of water used will be calculated using the following simple formula.

$Ar/Qa = x$ birr/m^3 of water used.

Where,
Ar = Annual Revenue required to run the system,
Qr = annual average water consumption.

Step 6 – Implementing the Rate

Once you have decided on a rate structure and appropriate rates, it is important to consider a number of other factors before charging your beneficiaries. Your rates may need to be adjusted because of the particular circumstances of your system. Factors to consider include:

1. Community's Perception: Beneficiaries should know what the rates are and should
2. Understand that they will be paying a fair and equitable share of the cost of providing safe drinking water. Make sure your beneficiaries understand that the system ability to provide safe drinking water depends greatly on having sufficient revenue, most of which comes from water sale. The beneficiaries must be informed throughout the rate setting process; informed beneficiaries are more likely to understand and tolerate rate increases.
3. Regulatory Requirements: Ensuring the water system has the resources to meet the country's drinking water requirements should be considered when setting rates.
4. Administration: The rate structure should be easy to administer. Complex structures may increase administrative costs and confuse beneficiaries.

Step 7 – Timing of tariff resets

The timing of tariff resets determines the length of time during which the water administration office (service provider) must bear risk before passing it on to customers. Three main approaches to the timing of tariff resets are possible:

a) Review on request

The timing of tariff resets is not set in advance. Resets are triggered at the request of an affected party, such as the water administration office /operator or a customer, if the operator's profitability diverges too far from a reasonable rate of return. In principle, this approach allows the water administration office /operator to pass changes in costs or revenues on to customers before the value of the business is significantly affected.

b) Periodic reviews

Permitted tariffs are reviewed and reset on a regular basis, say every five years. In principle, the water administration office /operator retains profits or losses earned between resets.

c) Event-based reviews

This approach is appropriate where the review seeks to adjust for specific variables. The arrangement specifies certain events that, if they occur, will trigger a tariff review. For example, the arrangement may specify that a tariff review will be held if demand varies from forecast by plus or minus 10 percent, if the local currency depreciates by more than 15 percent, or in response to changes in relevant legislation, for example on standards.

Hybrid approaches are also possible. Tariffs may be reviewed if certain events occur and one of the parties requests a review, or they may be reviewed in any case after a certain period if no event-based reviews have occurred.

It is also advisable to submit the rate structure for an independent review. Consider assembling a special review committee, since a review performed by an external party can be more transparent and impartial. Determining who should review the rate is an important part of the process.

1. Persons with management and budget experience are good candidates for the review committee.
2. Depending on RPS system, a review committee could include:
3. RPS system's operator
4. The WWRO
5. A professional from the community (e.g., accountant, lawyer, water system engineer)
6. A member of the /WASHCO & WUB
7. Beneficiaries
8. The manager of nearby area water supply service.

8.5.4.7 Provision of subsidies to tariffs

Another major financial obligation is related to compensating for tariffs that fail to cover the full financial costs of the utility.

Categories of subsidies

Subsidies can be categorised according to where the money comes from and who subsidies are paid to and for what. There are three sources of money for subsidies:

1. Revenue from other customers (usually called a **cross-subsidy** from one class of customers to another);
2. Government revenue, collected from taxpayers;
3. Grants from development agencies.

Cross-subsidy:

Cross-subsidy occurs when one customer pays more than the cost of service so that another customer can pay less. Cross-subsidies can be an effective way of achieving social goals, while ensuring that water utilities as a whole are self-financing. One of the most common types of cross-subsidy is the increasing-block tariff. Another common approach is to charge commercial and industrial customers more than the cost of service so that residential customers are charged less.

8.6 Daily Financial Management

8.6.1 Decision on Payment Method

Once the amount of water supply fee is determined, WASHCO will decide how to collect water supply fee. Let community users decide what method will work best for them. When the community helps to choose the method of collection and the amount to be collected, they are more likely to contribute.

The WASHCO should organise a general assembly to meet with the whole community to decide on how money is to be collected and managed.

8.5.3.1. Procedures to decide the payment method

- WASHCO organize a community consultative meeting,
- Woreda Water Office explains to users the importance of users contribution to O & M fund and possible payment options as per the manual,
- WASHCO facilitate users to discuss the following;
    - **Who Pays?** Some communities levy money from each individual adult; other communities levy money from each family or compound.
    - **Frequency:** Some communities with a regular income pay on a regular (e.g. monthly) basis; other communities (e.g. farming communities) pay on a seasonal basis (e.g. at harvest). Here, the pastoral areas practice applies.
    - **Amount:** Some communities collect the same amount of money from men and women; others collect different amounts from men and women. In general the amount of money to be collected as per the tariff calculation and principle of O&M cost recovery stated above for different water supply options. This must be explaining to the community by the WWO.

Households that cannot affordable to pay from economic reasons may be exempted from payment or accepted to pay reduced amount through communal decision. This implies that addressing equity for poor through subsidy or cross subsidy mechanisms.

8.5.3.2. When to collect Money?

When money is collected will depend on **when people have money to pay**. People who earn a regular income (e.g. traders) can pay on a monthly basis.

- Date of collection shall be fixed.

For example: every 25th date of each month.

Farmers, however, are more likely to contribute once a year at harvest. There may be a need to design different payment systems for the different sections of the community. Traders may want to pay a small amount after every market day, whereas farmers will prefer to pay a large amount at harvest. Pastoralist may be when selling livestock like goat. It depends on the preference of the user communities in particular local areas.

- Seasonal Variation of Water Fee

Some of WASHCO can handle water supply fee collection by setting different rates of water charge by season. Some cases indicate that each household pays Birr 1.0 per month during non-harvest season, while they agree to make payment of Birr 2.0 per household for six months after harvest.

8.5.3.3. Who to collect?

The number of collectors will depend on the size of the village and the payment system. If money is collected from each household, several collectors will be needed to go from house to house. If payment is done at a central location, then only a few collectors will be needed. The casher may visit each household to collect water supply tariff if the community size is small to cover.

- **Money collected should not stay with collectors for more than 24 hours.** Money should be paid to a casher of the WASHCO who deposit to the bank promptly.

- **Don't let the money be used by the collectors.** They may be tempted to take out some money for their own use with the intention to refund it immediately. If this practice is not stopped, however, the small amounts may build up to a huge sum that collectors cannot easily refund.

8.5.3.4. Any penalty to the non-payment

- Penalty shall be determined by the General Assembly.
- For example;
    - Penalty against the first failure in payment: Oral warning by WASHCO
    - Penalty against two consecutive failures in payment: Last warning by WASHCO
    - Penalty against three consecutive failures in payment: Measure to be taken by WASHCO (e.g., double payment)

8.5.3.5. Options for collection of O & M fund

- There are many ways to raise funds for O & M :

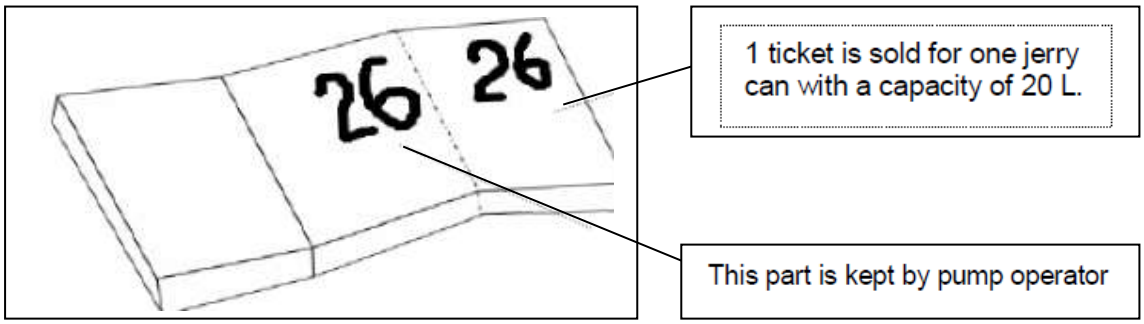
(i) CASH CONTRIBUTIONS:

(ii) **FLAT RATE;** this is the common method. Each household or individual makes a regular payment at fixed amount.

(iii) **BUCKET/JERRY CAN LEVY:** In some villages money is levied at the water point on each bucket/jerry can of water collected. For example, 10 cents per one Jerry can with 20 litter capacity. Any cash transaction should be transparent with proper accountability. In some case a ticket shall be used for this payment.

- Pump Operator shall prepare a pile of tickets.
- Each ticket has been piles in order with sequential number.

- A pump operator shall give collected cash with numbers of tickets that were sold to a cashier.



After cross-checking between an amount of cash and tickets, a cashier shall enter cash transaction into an account book.

Date	Description	In	Out	Balance
02/02/2008	XXXXXXXXXXXX	XXXX	XXXX	120.00
03/02/2008	Sales of waters (70 tickets)	14.00	0.00	134.00

(iv) **N-KIND CONTRIBUTIONS:** Some farming communities ask households to contribute in the form of produce on an annual basis (i.e. after harvest).

(v) **COMMUNAL FARMS OR LABOUR:** Some communities establish communal farms or organize communal labour to raise funds for maintenance.

8.5.3.6. Formulation of User Households List

WASHCO needs to have an updated list of all household users in the community. Based on that households list, WASHCO prepare "Household Payment List (see attached list) which can be used every month for record keeping.

Procedure

- WASHCO make a user household list (in a notebook) in collaboration with kebele chairman, kebele executives,
- WASHCO uses the above list to check when collecting O & M fee from user households,
- WASHCO needs to update regularly the household lists so as not to miss households who have newly joined in the community.

How to Use

(i) Money should be collected in a way that promotes trust!

- Payments should be carefully recorded in a register of payees and receipts should be issued for all payments. The minimum record of cash transaction should be kept by the casher that is accountable to users as well as WASHCO members. Based on experiences prevailing in the region, a sample form of minimum record is presented in Table below.

Table 8.2: WASHCO Basic Ledger of Water Fee Collection

No.	Name of Household	Rate of Water Fee in Birr	Month and Signature											
			1	2	3	4	5	6	7	8	9	10	11	12
1	Kebede Fiyissa	1.5 Birr/Month												
2	Alemu Abera	18 Birr/Year												
3	Delcho Data	9Birr/6 Months												

Some advanced WASHCO can also prepare a membership booklet as individual record of monthly payment of water fee.

Figure 8-1: Sample of household check book

8.6.2 Bank Account Opening

For proper and safe keeping financial resources, collected cash is deposited in an account of financial institution of either the nearest bank or micro-finance institute. WWO shall follow ordinary procedures in reference with their own experiences, so that each WASHCO can have its own the bank account or the Micro-Finance account soon as possible.

8.6.2.1 Procedure for Bank Account Opening

- WASHCO submits a letter of application to WWO
- Upon an official acknowledgement of the letter of application by
- WASHCO, the WWO issues a supporting letter to a financial institute.
- WASHCO goes with cash to the designated financial institute with the official supporting letter for opening an account.
- WASHCO is given a bank account book or statement by the financial institute.

8.6.2.2 Practical Tips

- Minimum requirement of cash to open a bank account

It is said that Birr 500 is required to open an account in a certain bank. Some cases can be shared herewith to respond to such conditions.

- Formulation and collection of seed money

Some of WASHCO succeeded in meeting this minimum requirement of Birr 500 through collection of seed money. In this case, each registered household shall contribute equal amount of money to form group fund. For instance, there is a case that more than 50 registered households accumulated Birr 500 through even contribution of Birr 10 per each household.

8.7 Management of Daily Cash Movement

The WASHCO will keep its own FINANCIAL RECORDS. The record-keeping system should be simple – mainly a record of payees and an accounts book to record monies collected and used.

8.7.1 Basic Elements of Financial Records

In any production and service giving organization, there exists a system of financial management whether complex or simple in their procedures. Financial accounting display and stress what an organization possess in terms of finance, property and assets and how it expended these resources at any point of time usually in a year.

In order to establish financial management system in an organization, the first step is to formulate and introduce different formats and books for financial data and interactive gathering so that all transactions and disbursements are clearly kept in registration and documentation books; which finally serve as input for financial reporting.

The basic account registration and documentation instruments required in financial management system are presented below.

8.7.1.1 Tool 1: Income and Expenses Book

This book is maintained and kept in the hand of the casher or secretary of the WASHCO. Then casher or secretary keep copies of receipts and payments and reconcile records in the income and expense books. Accordingly receipts and expenses are recorded by date, reasons and amounts and serial numbers in the income and expense books.

In the income and expenses books, invoices of receipts and payment vouchers are recorded according to their sequential serial numbers and coded to their budget line numbers.

Recording are kept daily in the income and expenses book and closing are processed on monthly basis.

The differences between income and expenses recorded in the account book are reconciled against cash in the hand and bank account.

Payment vouchers and receipt invoices should be maintained in separate files; payment vouchers in payment box files and receipts in a receipt box files. Filing should be according to sequenced numbers and box files should be labelled according to their orders say 1, 2, 3, - - - this will facilitate and expedite processes for internal audit and control activity.

An explanatory of the income and expenses book model are show below.

Table 8.3: Example of Income and Expense Book

Date	Details	Income	Expenditure	Balance		
				Cash	Bank	Total
02/01/08	Balance Forwarded from the previous month			-----	250.00	250.00
06/01/08	User fees	300.00		300.00	250.00	550.00
08/01/08	Stationery		40.00	260.00	250.00	510.00
26/01/08	Guard fee		100.00	160.00	250.00	410.00
30/01/08	Transportation to WWO		50.00	110.00	250.00	360.00
30/01/08	Deposit to the Bank(100Birr)			10.00	350.00	360.00
Total		**300.00**	**190.00**			

8.7.1.2 Tool 2: Cash Receipt Registration

- Cash receipt registrations are invoices issued for the cash amount paid for the water service by employees, other individuals or organization.
- Other revenues collected from sales of water at public fountains or on water consumption bills are also invoiced in the cash receipt registration.
- Receipt invoice pads should be printed in sequenced numbers in three duplicates. The original receipts are forwarded for payer; the copy is passed to the casher or tiller while the third copy shall remain in the pad.
- In the receipt first the date shall be filled, full name of the payer, signature of payee, and delegated authority are required.

The casher should keep the copy of the receipt in file and record in the book of the account all the details such as receipt number, date, reasons of receiving, amount in figures and words in sequence.

If receipts are invalid or when there is an error in the preparation of the receipt, the receipts is cancelled by writing **"CANCELLED"** diagonally across the face of the receipt.

A typical cash receipt registration form/ invoice is shown below.

Box 8-2: A typical cash receipt registration form/ invoice

XXXX Regional State,

XXXX Woreda Water Office

Xxx Water Supply Scheme

CASH RECEIPT INVOICE

No._____ Date:Tikimte 9, 2008

Name of payer: Tebikeu Meseret

Amount in figure: Birr 100.00

Amount in words: Birr Hundred

Payment Reason: Remuneration to the pump guardian

Prepared by: (Name and signature) _____

Name and signature of cashier: _____

Distribution:

- ✓ Original for payer
- ✓ Copy for cashier/tiller
- ✓ Second copy in the pad for account section

8.7.1.3 Tool 3: Cash Payment invoices/Vouchers

- Cash payment vouchers are legal documents for payment of cash approved and authorized by committee or Head of WWO.
- Before processing cash payment voucher, all supporting documents and invoices are carefully examined for completeness and then cash payment vouchers are signed by the secretary and chairperson of the WASHCO or Woreda account head and office superintendent on the amount for payment.
- Supporting documents for village water schemes or WWO could be - Purchase requisition or application for purchase of fuel oil and lubricant, the recommendation given by the committee or the office on the application and stores good receiving notes.
- For spare parts, the operator purchase application, the copy of water committee verbal for purchase of spares addressed for WWO and stores goods receiving models.
- Similar to cash receipt registration, cash payment pads are printed in sequence numbers in three duplicate and the original payment leaflet are attached with source document and kept in box files with cashers. The second copy of the payment leaf should be maintained in other box file for reconciliation for account head the third copy shall remain in the pad.
- In the cash payment voucher the following details should be presented, date, paid name, amount paid in numbers and words, reason for payment, prepared by, approving authority signature, recipient signature; moreover the recipient address and ID number if kept in the receipt are recommended.
- The account clerk maintaining payment registration should reconcile the source document against the voucher there by coding the expenses and record them in the book of expenses sequentially by date, voucher number, reason, amount and filing them in box files.

Box 8-3: A typical cash payment invoice form

XXXX Regional State,

XXXX Woreda Water Office

XXX Village WASHCO

CASH PAYMENT INVOICE

No.0001

Date: Meskerem 30, 2008

- Name of Payee: Alemitu Tulu
- Amount in Figure: Birr 1,500.00
- Amount in Words: Five Hundreds Birr only
- Payment Reason: For the purchase of office table and chair
- Prepared by: Bekele Godana
- Received by: _____
- Name & Signature_____
- Name & Signature of payee_____
- Approved / Authorized by_____
  Name & Signature_____

8.7.1.4 Tool 4: Payroll

Employees recruited and employed by the water committee or Woreda Water Offices are paid their salaries in pay rolls. Salary pay rolls are prepared for the number of days that employees are on duty in the month.

In processing pay roll all legal deductions such as income taxes and pension contributions are netted out from gross salary and passed to tiller. The casher effects payment for each employee with signing of pay roll by respective recipients.

Model of a payroll list is shown below.

Table 8-4: Model of Payroll List

No.	Name of Employee	No of days on duty	Gross Salary		Income Tax		Other Contribution		Total Deduction		Net Pay		Signature
			Birr	C	Birr	C	Birr	C	Birr	C	Birr	C	
1	Tolera Degefa	30	200	00	5	00	1	50	6	50	193	50	
2	Alemu Kebede	30	350	00	20	00	2	50	22	50	327	50	
3													
4													
5													

Prepared by Name and signature	Checked by Name and signature	Authorized by Name and Signature	Name and signature of Casher

Note: This payroll shall be prepared in excel spreadsheet!

8.7.1.5 Tool 5: Per Diem Payment Form

- Per-diem is the daily subsistence allowance and transport costs paid for employees to perform activities outside of the area. Per Diem payment form is prepared in one copy.
- Per diem and transport amount need to be clearly filled and authorized by signatures of the respective delegates such as secretary of committee and the chair person.
- Daily subsistence allowance rates are determined by internal delegation of water committee or government financial regulation that is operational in the region.
- The standard per diem payment forms is shown below

Box 8-4: A typical cash payment invoice form

XXX REGIONAL STATE

YYY Woreda Water Office

_____WASHCO

PER-DIEM PAYMENT FORM

Date: Meskerem.30, 2008

Per-diem Recipient Name: Geremew Bekele

Reasons for redeem payment: Training participation in WWO

Per diem amount per day in figure: 100.00 birr, in words: Hundred Birr

No of days allotted: 4 days

Total amount of per diem in fig. 400.00 Birr, in words Four Hundred Birr

Transport cost amount paid: 50.00 Birr, in words Fifty Birr

Total: 450.00 Birr (Four Hundred Fifty Birr) in words

Payer Name and Signature: Alemu Bekele

Received by: Kebede Zeleke

Approved and Authorized by: Kassa Ali

Document Prepared by: Tadesse Berega

8.7.1.6 Tool 6: Property Receiving Form (for Motorized Scheme)

Properties owned either through purchase by the water committee or earned in the form of grant, need to be recorded in the property receiving form by property administrator/ store keeper.

For purchased property (even if possible for granted items) details on unit prices, total prices and types of the property are required to be filled in the property receiving form.

No property shall be put into service without passing the property receiving records by the store keeper.

Table 8-5: Property Receiving Voucher Form

XXX REGIONAL STATE

YYY Woreda Water Office

_____Water Supply Scheme

No._____

Date: _____

PROPERTY RECEIVING VOUCHER

Supplier Name and Signature _____ (to store)

Ser. No	Description of Property	PR No.	Total No./Quty.	Unit Price (Birr)	Total Price (Birr)	Remark
1	Chlorine		50 kg	30.00	1,500.00	
				Total	**1,500.00**	

8.7.1.7 Tool 7: Property Registration Book (for Motorized scheme)

- The store keeper or the property administrator should record and copy all property receiving invoices to property registration book.
- When properties are withdrawn by property issue voucher, the property is recorded in the property registration book along with issue voucher number.
- The property registration books are permanent archives for the water supply service for control of the movement of the property and need to be kept reply for Woreda Water, Office supervisors and inventory purposes.

Table 8-6: Property Registration Book

XXX REGIONAL STATE

YYY Woreda Water Office

_____Water Supply Scheme

PROPERTY REGISTRATION BOOK

Ser. No	Property Description and type	Cost of the property (Birr)	Current statues			Remarks
			New	Serving	Old	
1	Chlorine	1,500.00	New			

8.8 Access to other sources of funding

"New strategies should aim towards increased efficiency in the use of available funds and in increased mobilization of additional funds." It will indeed be important to plan and determine financial mechanisms which cover all costs, if these are not fully covered by user's fees. As seen earlier, tariffs are often based on the recovery of basic operation and maintenance costs, and rarely include the cost for major repairs, rehabilitation and replacement. Communities will need to tap into alternative sources, and it is proposed that planners take this into account, and facilitate /organize access to these sources. Possible alternative financial sources are:

- existing community contributions,
- Cooperative Fund,
- subsidies and taxes,
- Credit–loan mechanisms,
- Grants,
- Specific funds.

This section gives an overview of these possible alternatives to tariffs. Government need to assess the availability, reliability and sustainability of these sources and, where they are non-existent, the possibility of developing them.

8.8.1 Tapping into existing community contribution

In communities with significant seasonal variations in income, it is difficult to recover costs through regular payments. An alternative is to cover the costs through community fund raising where "families do not pay regular contributions towards the cost of the community water system. Instead, money is periodically accumulated in other ways. Community fundraising options include voluntary funds, general community revenue and payment in kind.

a) Voluntary funds

Voluntary funds are built up by voluntary contributions from generous people or community groups through public meetings, bazaars, festivals and similar social activities.

b) General community revenue

This mentioned above that the community pays based on the set of tariff.

c) Payment in kind

Instead of contribution of money, the community contributes in terms of kind such as labor, local material provision.

8.8.2 Cooperative funds

Cooperative funds result from an initiative by a group of users or individuals who get together to finance productive activities, not in the first place always related to WS&S. The initial capital comes from contributions in cash or in kind from the members of the cooperative. Once the group has sufficient revenue, members may decide to use part of their funds to finance WS&S services. However, the amount of capital available in this option depends on the results of the first stage investments. With good financial and organizational practices, this is a good way to administer WS&S services.

8.8.3 Subsidies

a) Direct government subsidies

In fact the Water resources management policy stated that the O&M cost should be recovered by the users, however, the government still provide spare parts to the community, assisted the community in provision of technical, monitoring and evaluation activities.

Regional Water Bureaus allocate part of their budget towards operating and maintaining of rural water supply schemes, but the allocated budget is too low compared to the construction of new schemes.

Subsidies can be used as promotion tools for a particular professional group, for instance the informal and formal private sector. They can also be used to promote access to water services by marginalized groups, with subsidies adapted to various levels of marginalization.

b) Cross-subsidy

One way to make the service equitable and affordable for all is to subsidize the poor and surcharge high-income consumers. However, in rural and low-income urban areas the majority of users have low-income levels, so funds raised from surcharging richer users in that area will not cover their subsidies.

8.8.4 Grants

NGOs and donors have used grants as a type of financing mechanism for the construction of new water supply facilities. Grants rarely pay for recurrent costs. Nowadays, this approach should be changed and the NGOs and Donors provide grant for O&M in order to use the facilities sustainably. Grant should not be for basic O&M management.

8.8.5 Micro-credit

Micro-credit is financing through lending mechanisms, similar to credits given by banks, except for their nature and size. Micro-credits are generally small in volume and respond directly to the specific needs of rural or low-income urban communities.

- Credit and Saving Institute

A micro-credit system can be used to:

- contribute to investments,
- purchase material and equipment for replacement, extension and rehabilitation,
- finance major unforeseen repairs,
- cover short-term cash-flow problems;
- Develop a stock of spares, parts and tools.

The Amhara region has already commenced to implement the CSI and became effective.

There is rules and regulation for the fund, lending conditions, interest rate, and guarantee against risk, loan reimbursement, and limits of loan.

8.9 Financial Report

8.9.1 Report to the Community

The Executive Water Board / WASHCO must provide the overall performance report to the user communities every six months. One of the report is the financial report that shows the income and expenditure statement.

8.9.2 Reporting to Woreda Water Office

The Financial Report for each quarter by each EWB/WASHCO should reach to Woreda/Zone Water Offices, Water Bureau on the 5th of first month of the next quarter.

An interim financial report for each advance given to WAO or WASHCO shall be submitted by the WAO or WASHCO in the format illustrated. The following document must be attached with it:-

(i) Trial balance for the required reporting period;

(ii) A bank statement and a bank balance certificate showing the balance in the bank;

(iii) Cash balance in hand, and

(iv) A bank reconciliation statement for the period in question.

The Accounts Officer should retain copies of all documents listed above for office record. The retention of these documents is necessary for auditing purposes.

8.10 Auditing

8.10.1 General

Auditing is defined as a systematic and independent examination of data, statements, records, operations and performances (financial or otherwise) of point sources or RPS for a stated purpose. In any auditing the auditor perceives and recognizes the propositions before him for examination, collects evidence, evaluates the same and on this basis formulates his judgment which is communicated through his audit report. The purpose is then to give an opinion on the adequacy of controls (financial and otherwise) within an environment they audit, to evaluate and improve the effectiveness of risk management, control, and governance processes.

Auditing is a vital part of accounting in the financial management of RPS. Traditionally, audits were mainly associated with gaining information about financial systems and the financial records of a RPS.

Due to constraints, an audit seeks to provide only reasonable assurance that the statements are free from material error. Hence, statistical sampling is often adopted in audits. In the case of financial audits, a set of financial statements are said to be true and fair when they are free of material misstatements a concept influenced by both quantitative (numerical) and qualitative factors.

An audit must adhere to generally accepted standards established by governing bodies. These standards assure third parties or external users that they can rely upon the auditor's opinion on the fairness of financial statements, or other subjects on which the auditor expresses an opinion. Auditors of RPS's financial statements can be classified into two categories:

8.10.2 Legal Requirements for Auditing

According to the proclamation issued by the respective regional states on the establishment of rural water supply service and WASHCO, the mandate for auditing WASHCO/EWB should be applied.

8.10.3 Frequency of Auditing

The statutory audit of Water Administration Office/WASHCO will be carried out annually by authorized Accountant in accordance with appropriate auditing principles consistently applied.

The statutory auditor shall be appointed by the Regional Water Bureau, Zone Water Office or Woreda Water Office in association of Finance Bureaus and Office depending on the accountability of the Executive Water Board/WASHCO from the panel of Chartered Accountants maintained by Accountant General of the State.

8.10.4 Reporting of Auditing

The Executive Water Board/ Main WASHCO will review the annual audit reports of the Water Administration Office and issue necessary instructions to the respective WAO/WASHCO. The Executive Water Board/ Main WASHCO will submit its annual audit report, along with review notes on the WAO/Operator annual audit report to the General Assembly, Regional/Zone/Woreda Water Bureau/Offices, accordingly.

Annexes

Annex U: Reference

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Harold Lockwood and Stef Smits (2011), Supporting Rural Water Supply, Moving towards a Service Delivery Approach, IRC International Water and Sanitation Centre and Agua consult.

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Documentation of Proven Management Models for Multi Village Water Schemes, *Eyobe Defere & Getachew Abdi,* December, 2010.

Multi-Village Rural Water Supply Scheme, An emerging challenges, WSP, World Bank Document, 2013

Annex V: Basic Ledger of Water Fee Collection

No.	Name	Rate of Water Fee (Birr)	Month and Signature											
			1	2	3	4	5	6	7	8	9	10	11	12

Annex W: Income & Expense Ledger

Date	Details	Income	Expense	Balance		
				Cash	Bank	Total

Annex X: Income & Expense Ledger

Date	Details	Income	Expense	Balance		
				Cash	Bank	Total
Total						

Annex Y: Cash Receipt Registration

XXXX Regional State,

XXXX Woreda Water Office

Xxx Water Supply Scheme

CASH RECEIPT INVOICE

No._____ Date:_____

Name of payer: _____

Amount in figure: Birr _____

Amount in words: Birr _____

Payment Reason: _____

Prepared by: (Name and signature) _____

Name and signature of cashier: _____

Distribution:

- ✓ Original for payer
- ✓ Copy for cashier/tiller
- ✓ Second copy in the pad for account section

Annex Z: Cash Payment Invoice

XXXX Regional State,

XXXX Woreda Water Office

XXX Village WASHCO

CASH PAYMENT INVOICE

No.0001

Date: _____

- Name of Payee: _____
- Amount in Figure: Birr _____
- Amount in Words: _____
- Payment Reason: _____
- Prepared by: _____
- Received by: _____
- Name & Signature_____
- Name & Signature of payee_____
- Approved / Authorized by_____

  Name & Signature_____

Annex AA: Payroll List

No.	Name of Employee	No of days on duty	Gross Salary		Income Tax		Other Contribution		Total Deduction		Net Pay		Signature
			Birr	C	Birr	C	Birr	C	Birr	C	Birr	C	
1													
2													
3													
4													
5													

Annex BB: Per-diem Payment Form

XXX REGIONAL STATE

YYY Woreda Water Office

_____WASHCO

PER-DIEM PAYMENT FORM

Date: Meskerem.30, 2008

Per-diem Recipient Name: _____

Reasons for redeem payment: _____

Per diem amount per day in figure: _____ birr, in words: _____Birr

No of days allotted: _____

Total amount of per diem in fig. _____Birr, in words _____Birr

Transport cost amount paid: _____Birr, n words _____Birr

Total: _____Birr (_____ Birr) in words

Payer Name and Signature: _____

Received by: _____

Approved and Authorized by: _____

Document Prepared by: _____

Annex CC: Property Receiving Voucher

XXX REGIONAL STATE

YYY Woreda Water Office

_____Water Supply Scheme

No._____

Date: _____

PROPERTY RECEIVING VOUCHER

Supplier Name and Signature _____ (to store)

Ser. No	Description of Property	PR No.	Total No./Qty.	Unit Price (Birr)	Total Price (Birr)	Remark
1						
				Total		

Annex DD: Property Registration Form

XXX REGIONAL STATE

YYY Woreda Water Office

_____Water Supply Scheme

PROPERTY REGISTRATION BOOK

Ser. No	Property Description and type	Cost of the property (Birr)	Current statues			Remarks
			New	Serving	Old	
1	Chlorine	1,500.00	New			

Ministry of Water, Irrigation and Electricity
Directorate of Water Supply and Sanitation
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