TOOLBOX ON SOLAR POWERED IRRIGATION SYSTEMS (SPIS)

POWERING AGRICULTURE:

AN ENERGY GRAND CHALLENGE FOR DEVELOPMENT

Module 6: Set Up

Food and Agriculture Organization of the United Nations
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ABBREVIATIONS

Ah	Ampere hour
CWR	Crop Water Requirement
DC/AC	Direct Current / Alternating Current
ET	Evapotranspiration
FAO	Food and Agriculture Organization of the United Nations
Gd	Daily Global Irradiation
GIZ	Gesellschaft für Internationale Zusammenarbeit
GIWR	Gross Irrigation Water Requirement
GPFI	Global Partnership for Financial Inclusion
HERA	GIZ Program Poverty-oriented Basic Energy Services
H_T	Total Head
IEC	International Electrotechnical Commission
IFC	International Finance Corporation
IRR	Internal Rate of Return
IWR	Irrigation Water Requirement
MPPT	Maximum Power Point Tracking
NGO	Non-Governmental Organization
NIWR	Net Irrigation Water Requirement
NPV	Net Present Value
m^2	square meter
PV	photovoltaic
PVP	Photovoltaic Pump
SAT	Side Acceptance Test
SPIS	Solar Powered Irrigation System
STC	Standard Test Conditions
TC	Temperature Coefficient
UV	Ultraviolet
Vd	Daily crop water requirement
W	Watt
Wp	Watt peak

SET UP

1. Select a suitable installer
2. Plan site preparation and installation
3. Install
4. Acceptance test PVP
5. System test
6. Documentation
7. Hand over and user training

MODULE AIM & ORIENTATION

This module summarizes necessary steps for the installation of the Solar Powered Irrigation System. The design of the SPIS and the selection of the technology provider are completed (see **DESIGN** module). The installation of an irrigation system requires planning and decision-making by the producer, as the system should be set up according to set preferences and operation requirements. This module contains the relevant process steps to be taken to finally set up the system. In this module it is assumed that the technology provider is not necessarily the service provider for the installation of the SPIS.

PROCESS STEPS

With the signing of a contract or purchase order with a technology provider all decisions concerning the system components have been made. The quotation or offer from the provider should include a system layout plan in which the specific installation requirements are described. The practical installation is often not done by the producer. Instead, a qualified installer is required to assemble and mount the system components as required. A good quality installation lays the foundation for the reliable operation of the SPIS, taking into consideration the specific site conditions. The installation process will require active decision-making by the future user (i.e. the SPIS client or agricultural producer).

The set up or installation starts with choosing a suitable service provider. Then a detailed planning of the necessary works has to be made. In the installation planning, all requirements of the producer and the installer will be considered. Once the system components are installed, their proper functioning and the systems overall performance have to be tested.

The producer, as the future user of the system, has to follow this process closely to assure that the SPIS is installed according to the agreed planning and also to understand the system's functionality. Upon completion of the installation, the producer should insist on receiving appropriate documentation of the system and a personal introduction to its operation.

1. SELECT SUITABLE INSTALLER

The installation itself should be considered when selecting the technology provider. The quotations submitted by the equipment providers need to specify whether the system installation is included. If the installation services are included in the contract for the system components, the provider would nominate an installer.

When technology providers do not do the installation directly, they should recommend a qualified installer and a separate contract for the installation services has to be concluded. For this, a pre-selection of qualified installers should be established and quotations or offers for the services should be obtained, evaluated and decided upon (see **DESIGN** module).

Installers need to be chosen based on their general qualification and familiarity with the specific products (system components) the producer has opted for. Some technology providers only allow installation by certified installers as part of their warranty conditions and hence, should recommend certified service providers.

In order to make an offer, the installer visits the site and reviews the planned installation together with the producer.

When selecting suitable installers:

- check if the technology provider is able to recommend a qualified installer from his network;
- verify if the installer is certified for the installation of the purchased system components / brands;
- check the experience of the installer with installations in your area (reference list, other producers);
- obtain clarity on the installers' after installation services and whether they are available for maintenance, troubleshooting and repair.

OUTCOME / PRODUCT

- Shortlist of qualified installers;
- quotations / offers for installation services;
- selection of installer based on cost-quality considerations;
- installation services contract.

DATA REQUIREMENTS

- List of qualified and certified installers from technology provider;
- system layout and system component description (provided in contract with technology provider);
- unit price listing (quotation / offer of installer);
- information on post-installation services.

PEOPLE / STAKEHOLDERS

- Producer;
- supplier / system integrator (technology provider);
- installation service provider;
- agricultural service provider.

IMPORTANT ISSUES

- Installation may be included in the purchase contract for the system components, but may also have to be contracted separately.
- It may not be feasible that the same installer is able to install PV generator, pump, storage tank and irrigation system.
- The warranty of the system components depends on the installation by a qualified and certified service provider.
- It is recommended to work with an installer who can also provide maintenance, troubleshooting and repair services.

2. PLAN PREPARATION AND INSTALLATION

The selected installer is required to consider the site-specific conditions in his quotation or offer. In this process step, he should already have taken into account the views of the producer with regard to the location, spacing and protection of the planned system. After conclusion of the installation service contract, a detailed planning of the installation has to take place.

For this, a further site visit and joint review of all relevant aspects may be required in cooperation with the producer.

The aim of this installation planning is to:

- verify site access and material storage conditions;
- determine the exact planned location and the spacing of the system components (PV generator, water pump, control units, water storage tank, water distribution network, irrigation pipes);
- assess the site-specific conditions relevant for the installation (soil / underground conditions, surface profile, water source conditions, security hazards);
- identify preparatory works to be done (de-installation of old installations, well-cleaning / rehabilitation and pumping tests, earth works, site clearing, field preparation);
- plan preparatory works and installation;
- identify health and safety precautions.

A proper pre-installation planning helps avoid delays in the installation process because preparatory works and installation can be timed in succession. The producer may also have some particular additional considerations with regard to location, spacing and protection of the future system, which have to be taken into account by the installer prior to assembling and mounting the components. Specific site conditions, such as exposure to strong winds, flood water, stray animals or risks related to theft or vandalism (see **GET INFORMED**, mounting structure) are factors that influence the installation and the materials to be used (lock tie nuts, spray, seals, etc.).

The installation planning must also be harmonized with the cropping calendar and the agricultural work schedule of the specific farm household (see **DESIGN**, process step 2). Installation works should not disturb the production routine in an unnecessary way.

If more than one installer is required (for example one for the PV pumping system and one for the irrigation system components), the planning needs to take this into account. The work of the different installers must be coordinated.

The required land resources to establish the SPIS are often underestimated. The PV generators and the water storage tank (if part of the system) will occupy land that is otherwise available for cultivation. The system components must be spaced in a way that the solar panels are not shadowed by neighboring components, or that there is enough space to reach specific parts for maintenance, for example.

Note*:* System integrators estimate that about double the area covered by solar panels should be reserved for proper operation and maintenance. This is necessary to allow for space required by fencing, moving around the installation for maintenance, and reduce the impact of shading.

The planning in cooperation with the installer should also result in a clear understanding of both parties on the process of handing over the system and the provision of an orientation training of the user upon handover.

OUTCOME /PRODUCT

- Location of each system component;
- list of preparatory works / requirements;
- schedule for preparatory works and installation;
- schedule for hand over and user training.

DATA REQUIREMENTS

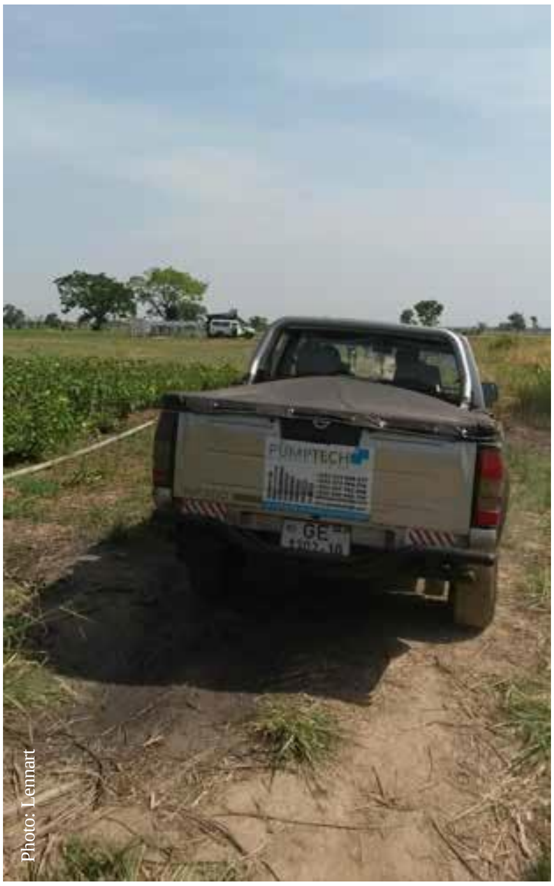
- System layout plan (provided in contract with technology provider);
- data on well / water source conditions;
- data on soil / underground conditions.

PEOPLE / STAKEHOLDERS

- Producer;
- installation service provider;
- agricultural service provider.

IMPORTANT ISSUES

- Implementation planning requires a site visit of the installer and a joint review with the famer.
- Site-specific conditions and hazards need to be considered.
- Land resources are required for the installation.
- Preparatory works requirements have to be identified prior to installation.
- Preparatory works need to be concluded prior to installation.
- Installation planning should include handover and user training timing;
- Multiple installers may need to be coordinated.



Installer visiting an SPIS site in Tamalé, Ghana (Source: Lennart Woltering)

3. INSTALL

The installation of the different components of a Solar Powered Irrigation System will be carried out by a contracted qualified installer. The installer will follow the system layout and the technical specifications provided from the system technology service provider (system integrator, supplier) and the considerations of the producer with regard to location and spacing.

The installer will temporarily require access to the site and a storage and assembly space to unload and assemble the system components. This should be considered by the producer in particular on small holdings where uncultivated areas are in short supply.

The actual time required for the assembly and the mounting and connection of the different components of an SPIS depends on system size and site conditions. The installer may have to carry out the installation process in several steps. A time consuming partial work is the establishment of a proper foundation for the mounting structure of the solar panels and the water storage tank (if part of the system).

These foundations are often established with reinforced concrete foundations that might require prior excavations works and curing time of cement after casting.

It is very important that the producer, and if possible also the agricultural advisor, take time to be present during the set up of the system, so that they:

- are available to provide information and to take decisions;
- can check on the completeness of all components while they are installed;
- obtain an additional understanding of the different system components, their particularities and the location of connections; switches etc. (ask questions!);
- can monitor the adherence of the installation to layout, plan and schedule (component compliance) or take note of any deviations from that due to unforeseen circumstances.

OUTCOME / PRODUCT

- Complete Solar Powered Irrigation System.

DATA REQUIREMENTS

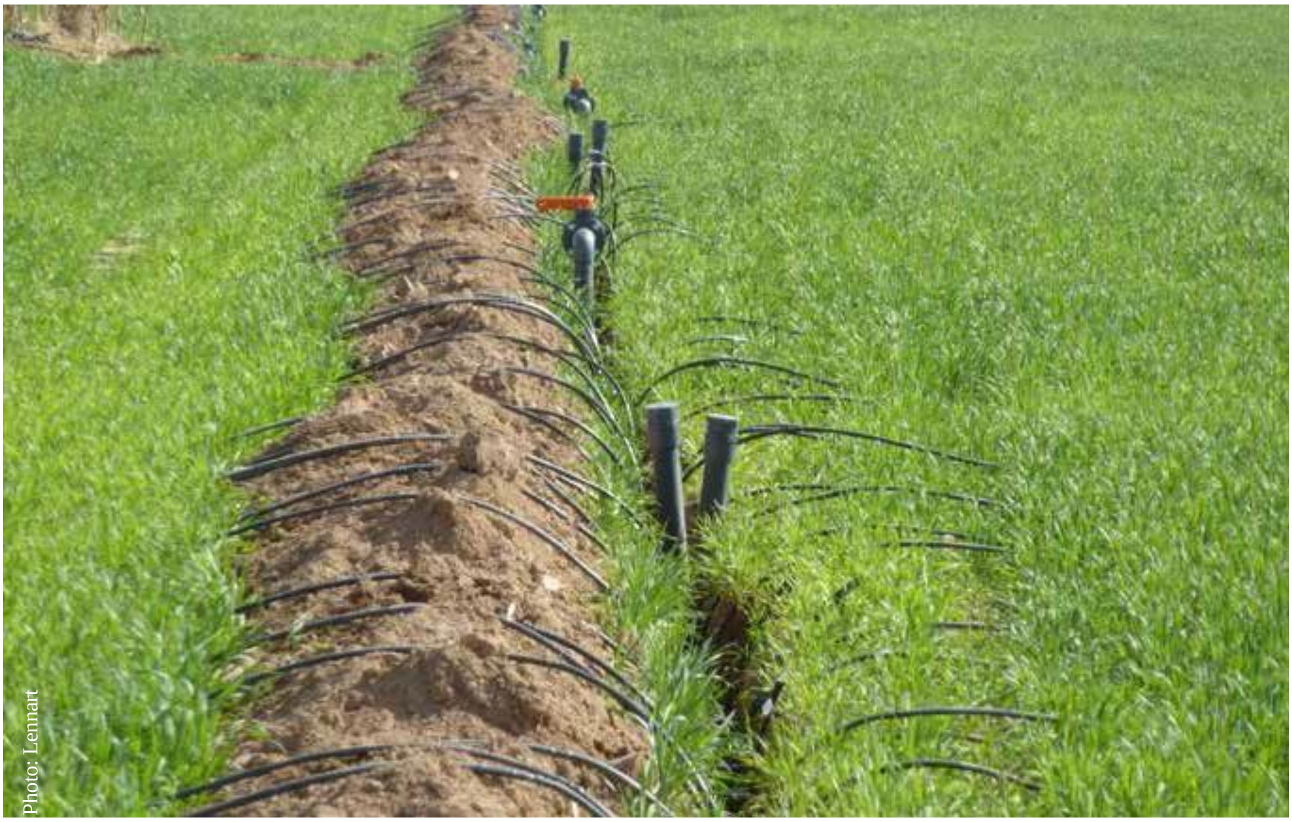
- System layout plan (provided in contract with technology provider);
- list of components and bills of quantity;
- installation planning.

PEOPLE / STAKEHOLDERS

- Producer;
- installation service provider;
- agricultural service provider.

IMPORTANT ISSUES

- Temporary space has to be made available for site access, material storage and assembly.
- Installation may have to be made in separate steps if foundation works etc. have to be done.
- The producer should be present during the installation and accompany and monitor the process.



Installation of a drip irrigation system

(Source: Lennart Woltering)

4. ACCEPTANCE TEST PVP

Upon completion of the installation, the functionality and the performance of the system should be tested in the presence of the future user (producer). The testing includes a number of separate analyses. The first step is the acceptance test for the photovoltaic pumping system (PVP) which includes the PV generator, the mounting and tracking system (if part of the system), the controller and the water pump. These components are the "engine" of the SPIS, their performance is vital for the successful use of the irrigation system.

This acceptance test (also referred to as Site Acceptance Test, SAT) is the second level of material testing in view of quality management. Manufacturers of system components are obliged to run a Factory Acceptance Test (FAT) prior to releasing products to the supplier. Ideally, both levels of testing should be presented when evaluating an SPIS, but are not always readily available.

The acceptance test for the PVP includes the following main steps:

- visual check of all main components and their joints / connections;
- visual check of wiring and insulation;
- mechanical check of mounting and tracking system;
- functional check of PVP operation;
- functional check of the PVP electronic controller
- existence of system documentation (technical data sheets, electrical wiring plan, operational procedures);
- measurement of solar irradiance, electric power, pumping head and water flow so that the difference between calculated flow and actual measured flow can be established.

The measurements are usually carried out in the following sequence:

Measurement of solar irradiance --> Calculation of electrical power output--> Measurement and calculation of total pumping head --> Measurement of actual water flow ---> Comparison of measured and designed water flow

The different measurements should be carried out within a short time interval under clear sky conditions. At least two acceptance test runs are advisable, measuring at high irradiance (800 – 1,000 W/m2) and low irradiance levels (approx. 500 W/m^2). The equipment for the test will be provided by the installer.

Important: Check on the tightness of seals and joints, screws and bolts.

Check for signs of corrosion and cracked concrete foundations.

Check for leaking pipes and fittings.

Record any deficiency and malfunction and discuss their amendment with the installer by the installer!

The results of the acceptance test should be compared with the design performance of the PV pumping system. The **DESIGN – Pump Sizing Tool** could be used to record the most important data and to compare it with the design values. The acceptance test protocol should be signed by the installer and the producer.

The tool **SET UP – PVP Acceptance Test** provides more details on the steps, required equipment and calculations involved in the acceptance test.

OUTCOME / PRODUCT

- Completed acceptance test for the photovoltaic water pumping system;
- comparison of actual performance to design performance;
- acceptance test protocol:

- **SET UP – PVP Acceptance Test**.

DATA REQUIREMENTS

- Measured solar irradiance, total pumping head and water flow;
- calculated electrical power output, design, pumping head and design water flow;
- observations from visual check.

PEOPLE / STAKEHOLDERS

- Producer;
- installation service provider;
- agricultural service provider.

IMPORTANT ISSUES

- The on-site acceptance test is mandatory to verify if the PVP systems achieves design performance.
- Testing should be done by the installer in presence of the producer considering all relevant criteria.
- Testing requires clear sky conditions, a minimum of two measurements need to be done.
- A thorough check on the mechanical parts is recommended.

Measuring the irradiance during the Site Acceptance Test (Source: Reinhold Schmidt)

5. SYSTEM TEST

After the testing of the PV generator, the functionality of the other system components and their joint functionality must be checked and tested. This testing step should follow the same principles as the preceding PVP acceptance test. At least the following should be tested:

- water abstraction and discharge monitoring devices (water meters);
- distribution valves, distribution pipes and connectors;
- reservoir and filters (if part of the system);
- irrigation pipes and watering devices (emitters, mini sprinklers) by doing a Water Application Uniformity test (see Tool **MAINTAIN – Water Application Uniformity Field Guide**).

The system test for the aforementioned components includes:

- Visual checks (bolts and screws, etc.);
- mechanical check of mounting supports for tank and pipelines;
- functional check of water distribution and discharge, storage tank and filter operation;
- functional check of maintenance modus;
- existence of system documentation (technical data sheets, hydraulic plan, operational procedures);
- measurement of water pressure input and pressure distribution in all system sections and water discharge.

Measurements are usually carried out “from head to tail”, starting with the release of the water into the supply line (to storage tank or direct injection) and ending with the flushing outlets of the irrigation pipes. Pressure measurements have to be taken at all system joints / distribution knots to assess the hydraulic distribution in all sections. These measurements have to take into account the pressure variation during the day caused by fluctuating irradiance levels. The results need to be documented as a hydraulic profile of the irrigation system.

Calibration: The water discharge to the field needs to be calibrated in order to manage crop water distribution efficiently. Pressure differences may exist between different sections of the irrigation system and the pressure inputs vary in a PV pumping system without elevated storage, causing water discharge from the irrigation devices to differ from section to section and within the course of a day. The water discharge from the irrigation devices has to be measured at different times of the day to calculate the actual water discharge, which can then be managed by varying the irrigation interval per area unit.

Note: This calibration measurement is a time consuming exercise!

Considerable differences between the designed and actual performance can be a sign for a poor design (collected data, poor choice of component, etc.) or poor workmanship. Quality of workmanship has a direct influence on system performance and sustainability, and poor workmanship can compromise even the best system components. The Tool **SET UP – Workmanship Quality Checklist** comprises various workmanship indicators clustered into different categories. The purpose is to assess whether quality of installation adheres to best practices, safety requirements and overall installation sustainability.

OUTCOME / PRODUCT

- Completed system test for the irrigation system;
- comparison of actual performance to design performance;

- system test protocol;
- hydraulic profile of the irrigation system;
- water discharge data for all irrigation sections.

DATA REQUIREMENTS

- Measured pressure and water discharge in all irrigation sections;
- calculated system pressure and water discharge;
- observations from visual check.

PEOPLE / STAKEHOLDERS

- Producer;
- installation service provider;
- agricultural service provider.

IMPORTANT ISSUES

- The on-site system test is mandatory to verify whether the irrigation systems achieve design performance.
- Testing should be done by the installer in presence of the producer.
- Testing must include pressure and water discharge measurements in all irrigation sections.
- Calibration of the irrigation discharge system is important to efficiently manage crop water distribution.

Measuring water flow

(Source: Reinhold Schmidt)

6. DOCUMENTATION

An SPIS comprises multiple components that have particular technical specifications and operation and maintenance requirements. Indeed, some mechanical and electrical technology may be vulnerable to defects if operated wrongly. Careful operation of the system not only prevents system failure and costly repairs, but also assures a longer lifespan. While technical data sheets and installation instructions exist most individual SPIS components, operational manuals covering an entire system are the exception. Since an SPIS is designed for an individual case, the operation and maintenance manuals should be customized.

Comprehensive documentation of the system and its operation and maintenance needs to be provided by the supplier and the installer during the acceptance, system test or final hand-over! This should be agreed on with the technology provider and/or the installer during contract negotiations.

The documentation should cover the following main aspects:

- system layout plan including all components of the water source, pumping system, water storage and irrigation system (and connection and wiring plans);
- technical data sheets for all system components including a recording of serial numbers of modules and other components, for example to claim ownership when submitting an insurance claim;
- operational guidelines for all system components;
- warranty information and maintenance instructions and schedules for all system components;
- security instructions, health risk warnings and emergency procedures;
- contact details of maintenance / repair services, help desks etc.

Ideally, the operational manual also includes information about the negative implication of excessive water abstraction for the environment. A systematically designed irrigation system operates on the principle of a sustainable water abstraction in line with the available water resources and the underlying water rights / permits.

OUTCOME / PRODUCT

- Documentation of all SPIS components including technical specifications, connection/ wiring plans, security instructions, emergency procedures and maintenance information;
- system operation manual;
- emergency contact details / help desk information.

DATA REQUIREMENTS

- Technical specifications of SPIS components.

PEOPLE / STAKEHOLDERS

- Producer;
- installation service provider;
- agricultural service provider.

IMPORTANT ISSUES

- The documentation of all system components must be complete and understandable.
- Security and emergency instructions should be clearly indicated and visibly attached to the respective system component.
- The installer should provide an operational manual with all relevant procedures and information.

7. HAND-OVER AND TRAINING

The final step of the installation process is to formally hand over the SPIS to the user (producer). The handing-over is usually combined with a thorough introduction to all technical aspects of the system and a practical training on its operation as per the designed performance. This step should be thoroughly planned because the user should have sufficient time to go through all system components and operation and maintenance aspects together with the technicians of the installer.

Prior to this step, all other requirements should have been completed, in particular the PVP acceptance and the system tests and the system's documentation. Ideally, the user could accompany and follow the entire installation process including the testing steps. This way they will already have obtained knowledge about their system and will have had the opportunity to be familiarized with the main technical and operational features.

During the testing stages of the installation process, defects or quality problems are identified and recorded and an agreement between the installer and the user is concluded on how and when these defects are corrected. This is laid down in the test protocols. A handing over of the system should not take place before all repairs and amendments are implemented.

The handing-over and the related instruction and training usually take place during a final test run of the system. It should not be done as a theoretical class room exercise. Supporting material for the training should consist of the operational guidelines and the manual that is provided as part of the system's documentation.

Important features of the orientation and training are:

- introduction to the specifics of all system components;
- operation of the system under different conditions, in particular crop water distribution management based on pressure and supply duration management;
- security precautions and protection of system components;
- health and environmental hazards;
- emergency procedures;
- maintenance works and schedules.

The handing over should be concluded by signing a hand over protocol that states the condition of the system and all activities carried out to instruct and train the producer.

OUTCOME / PRODUCT

- Hand-over protocol.

DATA REQUIREMENTS

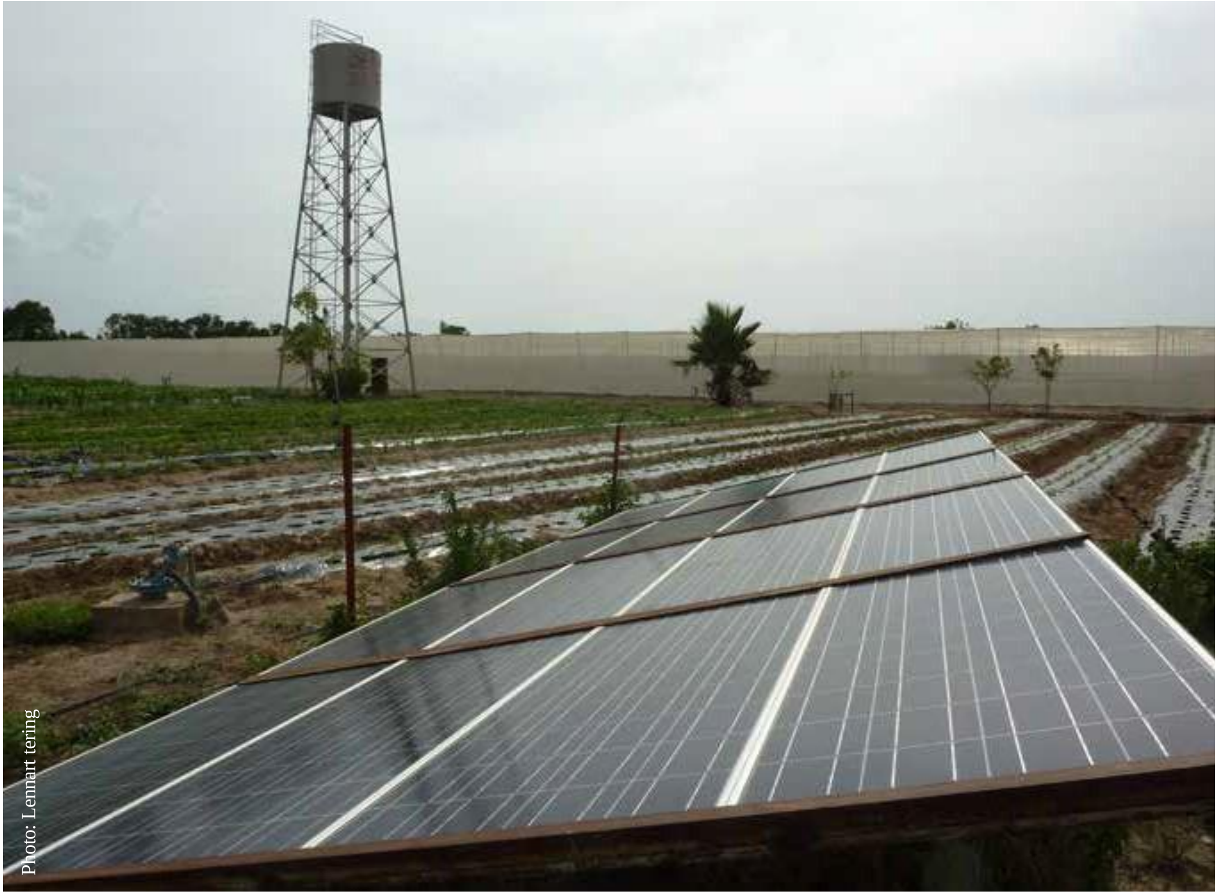
- PVP acceptance and system test data;
- system documentation and operation manual.

PEOPLE / STAKEHOLDERS

- Producer;
- installation service provider;
- agricultural service provider.

IMPORTANT ISSUES

- Hand over should only take place if the system is perfectly running, with no remaining deficiencies.
- Hand over should be accompanied by a practical introduction and training of the user including information on security precautions, system protection and hazards.
- A hand-over protocol should be prepared and signed



SPIS with an elevated reservoir used for irrigation in- and outside of the greenhouse (Source: Lennart Woltering)

FURTHER READING, LINKS AND TOOLS

Links

Centre for Land and Water: Knowledge Resources for Primary Industry. Retrieved from http://www.claw.net.nz/resources/irrigation/

Hahn, A., Sass, J. & Fröhlich, C. (2015): Manual and tools for promoting SPIS. Multicountry - Stocktaking and Analysis Report. GFA Consulting Group. Retrieved from [currently under revision]

Schultz, R. & Suryani, A. (2015): EnDev2 Indonesia: Inspection Guide for Photovoltaic Village Power (PVVP) Systems. Edited by GIZ. Retrieved from https://energypedia.info/images/3/39/Inspection_Guide_for_PVVP_150524_%28GIZ_2015%29.pdf

SPIS tools

SET UP – PV Acceptance Test: Guideline to compare the installed with the actual capacity of the pump

SET UP – Workmanship Quality Checklist: Checklist for inspecting and verifying the workmanship quality

The following tools that are assigned to other Modules are also relevant:

PROMOTE – SPIS Rapid Assessment: on the analysis of the market for service provision

DESIGN – Pump Sizing Tool: to verify SPIS acceptance testing

MAINTAIN – Water Application Uniformity Guide: that should be implemented directly after setting up the system

TECHNICAL GLOSSARY

Aquifer	Underground geological formation(s), containing usable amounts of groundwater that can supply wells or springs for domestic, industrial, and irrigation uses.
Chemigation	The process of applying chemicals (fertilizers, insecticides, herbicides, etc...) to crops or soil through an irrigation system with the water.
Conveyance loss	Loss of water from a channel or pipe during transport, including losses due to seepage, leakage, evaporation, and other losses.
Crop coefficient	Ratio of the actual crop evapotranspiration to its potential (or reference) evapotranspiration. It is different for each crop and changes over time with the crop's growth stage.
Crop Water Requirement (CWR)	The amount of water needed by a plant. It depends on the climate, the crop as well as management and environmental conditions. It is the same as crop evapotranspiration.
Current (I)	Current is the electrical flow when voltage is present across a conductor, or the rate at which charge is flowing, expressed in amperes [A].
Deep percolation	Movement of water downward through the soil profile below the root zone. This water is lost to the plants and eventually ends up in the groundwater. [mm]
Drawdown	Lowering of level of water in a well due to pumping.
Drip irrigation	Water is applied to the soil surface at very low flow rates (drops or small streams) through emitters. Also known as trickle or micro-irrigation.
Emitter	Small micro-irrigation dispensing device designed to dissipate pressure and discharge a small uniform flow or trickle of water at a constant discharge which does not vary significantly because of minor differences in pressure head. Also called a "dripper" or "trickler".
Evaporation	Loss of water as vapor from the surface of the soil or wet leaves. [mm]
Evapotranspiration (ET)	Combined water lost from evaporation and transpiration. The crop ET (ETc) can be estimated by calculating the reference ET for a particular reference crop (ETo for clipped grass) from weather data and multiplying this by a crop coefficient. The ETc, or water lost, equals the CWR, or water needed by plant. [mm]
GIWR	The Gross Irrigation Water Requirement (GIWR) is used to express the quantity of water that is required in the irrigation system. [mm]
Fertigation	Application of fertilizers through the irrigation system. A form of chemigation.

Financial viability	The ability to generate sufficient income to meet operating expenditure, financing needs and, ideally, to allow profit generation. It is usually assessed using the Net Present Value (NPV) and Internal Rate of Return (IRR) approaches together with estimating the sensitivity of the cost and revenue elements (See Module **INVEST**).
Friction loss	The loss of pressure due to flow of water in pipe. It depends on the pipe size (inside diameter), flow rate, and length of pipe. It is determined by consulting a friction loss chart available in an engineering reference book or from a pipe supplier. [m]
Global solar radiation (G)	The energy carried by radiation on a surface over a certain period of time. The global solar radiation is locations specific as it is influenced by clouds, air humidity, climate, elevation and latitude, etc. The global solar radiation on a horizontal surface is measured by a network of meteorological stations all over the world and is expressed in kilowatt hours per square meter [kWh/m^2].
Gravity flow	The use of gravity to produce pressure and water flow, for example when a storage tank is elevated above the point of use, so that water will flow with no further pumping required.
Head	Value of atmospheric pressure at a specific location and condition. [m]: Head, total (dynamic) Sum of static, pressure, friction and velocity head that a pump works against while pumping at a specific flow rate. [m]; Head loss Energy loss in fluid flow. [m]
Infiltration	The act of water entering the soil profile.
Insolation	The rate at which solar energy reaches a unit area at the earth measures in Watts per square meter [W/m^2]. Also called solar irradiance.
Irradiation	The integration or summation of insolation (equals solar irradiance) over a time period expressed in Joules per square meter (J/m2) or watt-hours per square meter [Wh/m^2].
Irrigation	Irrigation is the controlled application of water to respond to crop needs.
Irrigation efficiency	Proportion of the irrigation water that is beneficially used to the irrigation water that is applied. [%]
Irrigation head	Control unit to regulate water quantity, quality and pressure in an irrigation system using different types of valves, pressure regulators, filters and possibly a chemigation system.
Lateral	Pipe(s) that go from the control valves to the sprinklers or drip emitter tubes.
Latitude	Latitude specifies the north–south position of a point on the Earth's surface. It is an angle which ranges from 0° at the Equator to 90° (North or South) at the poles. Lines of constant lati-

	tude, or parallels, run east–west as circles parallel to the equator. Latitude is used together with longitude to specify the precise location of features on the surface of the Earth.
Leaching	Moving soluble materials down through the soil profile with the water.
Maximum Power Point Tracking (MPPT)	An important feature in many control boxes to draw the right amount of current in order to maintain a high voltage and achieve maximum system efficiency.
Net Irrigation Water Requirements (NIWR)	The sum of the individual crop water requirements (CWR) for each plant for a given period of time. The NIWR determines how much water should reach the crop to satisfy its demand for water in the soil. [mm]
Power (P)	Power is the rate at which energy is transferred by an electrical circuit expressed in watts. Power depends on the amount of current and voltage in the system. Power equals current multiplied by voltage (P=I x V). [W]
Photosynthesis	Photosynthesis is a process used by plants and other organisms to convert light energy into chemical energy that can later be released to fuel the organisms' activities (energy transformation).
Pressure	The measurement of force within a system. This is the force that moves water through pipes, sprinklers and emitters. Static pressure is measured when no water is flowing and dynamic pressure is measured when water is flowing. Pressure and flow are affected by each other. [bars, psi, kPa]
Priming	The process of hand-filling the suction pipe and intake of a surface pump. Priming is generally necessary when a pump must be located above the water source.
Pump	Converts mechanical energy into hydraulic energy (pressure and/or flow). Submersible pump: a motor/pump combination designed to be placed entirely below the water surface. Surface pump: pump that is not submersible and placed not higher than about 7 meters above the surface of the water.
Root Zone	The depth or volume of soil from which plants effectively extract water from. [m]
Salinity (Saline)	Salinity refers to the amount of salts dissolved in soil water.
Solar panel efficiency	Solar panel efficiency is the ratio of light shining on the panel, versus the amount of electricity produced. It is expressed as a percentage. Most systems are around 16% efficient, meaning 16% of the light energy is converted into electricity.
Suction lift	Vertical distance from the surface of the water to the pump. This distance is limited by physics to around 7 meters and should be minimized for best results. This applies only to surface pumps.

Surface irrigation	Irrigation method where the soil surface is used to transport the water via gravity flow from the source to the plants. Common surface irrigation methods are: Furrow irrigation – water is applied to row crops in small ditches or channels between the rows made by tillage implements; Basin irrigation – water is applied to a completely level area surrounded by dikes, and Flood irrigation – water is applied to the soil surface without flow controls, such as furrows or borders.
Transpiration	Water taken up by the plant's roots and transpired out of the leaves. [mm]
Voltage (U or V)	Voltage is the electric potential between two points, or the difference in charge between two points, expressed in Volts [V].