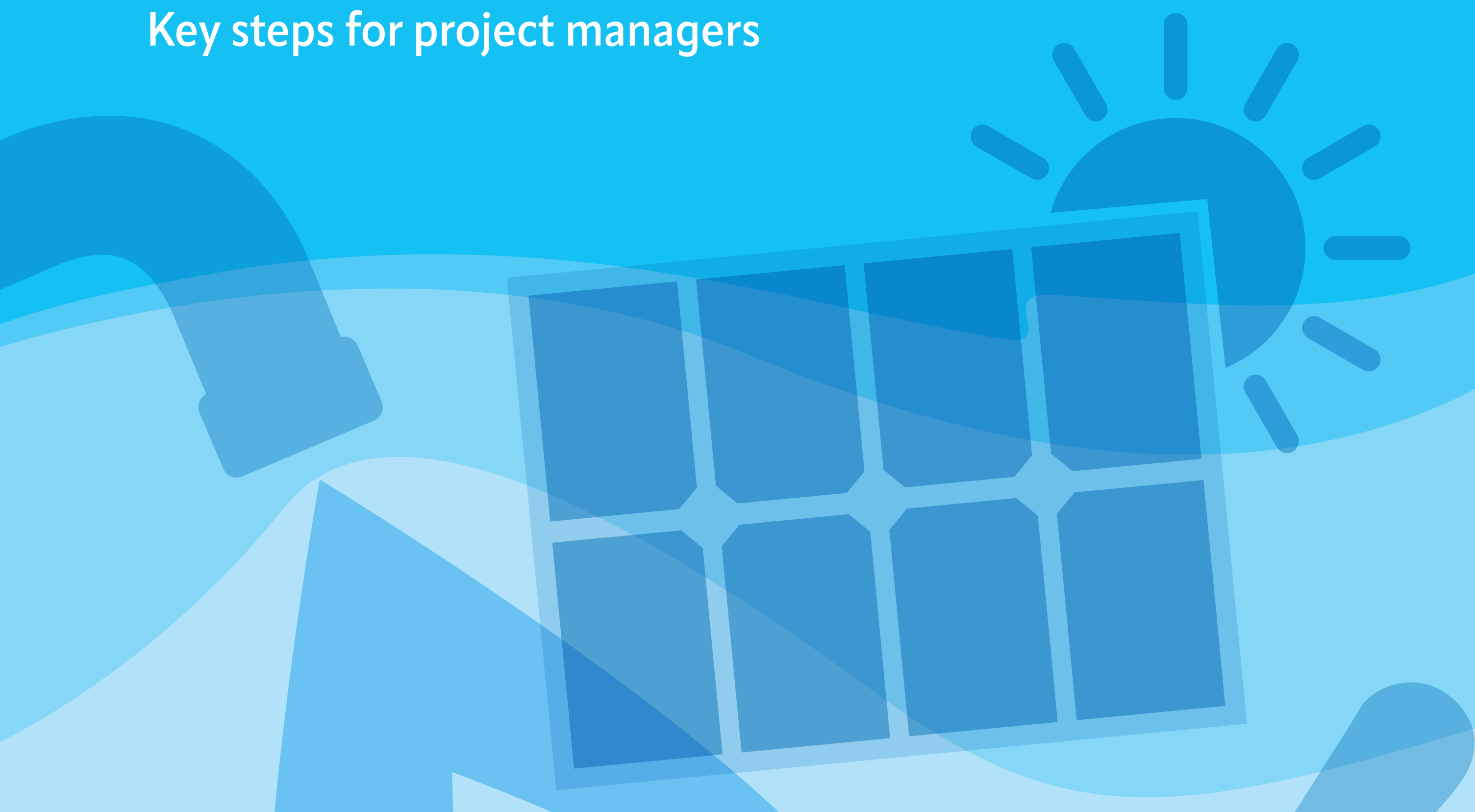
Sustainable solar pumping for existing water supply systems

Key steps for project managers



This technical guide is aimed at project managers wishing to solarise an existing water point. It sets out the key steps to be taken to optimise the system's chances of success and sustainability.

01

STAGES IN THE DESIGN

Preliminary checks

- Ensure that the water supply system is part of sustainable resource management (hydrogeological study of the catchment area, aquifers, recharge and water quality).
- Assess the site in terms of space required/available, safety aspects, shadow-free clearance for solar panels, sources of contamination of the water point, etc.
- Check that the project complies with national directives and technical specifications.
- Find out whether technical capacity, equipment and spare parts are in available in the region/country.
- Verify societal feasibility: inclusion and ownership of the project by beneficiaries, availability and training of technical staff, etc.
- Make sure that an investment budget including operating and maintenance costs is available for a period of 5 to 10 years.

Determination of water demand and operating period

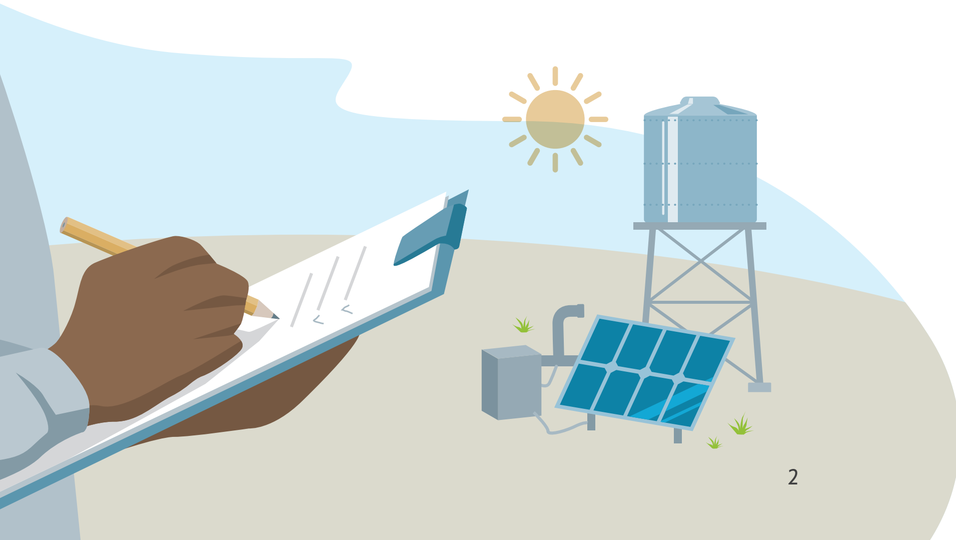
- Calculate the daily volume of water required and define the time horizon so as to be able to take account of changes in future water requirements. It is recommended that this planning be carried out over a period of 5 to 10 years. This corresponds to the period when major parts of the equipment (pump, inverter, etc.) will have to be replaced.

Specification of the characteristics of the water point

- Gather information about the water source.
In the case of a borehole: depth, diameter, position of well screens, static level, seasonal variations, results of pumping tests (at least a step-drawdown test to define the characteristics of the borehole, the critical and the safe yield; possibly a constant-rate test to define the hydrodynamic characteristics of the aquifer).
- It is essential to carry out/repeat a borehole inspection (by camera) and a step-drawdown test when there is missing information or if the borehole has already been in operation for many years.

Definition of the reference month

- In general, the reference month corresponds to the month with the lowest solar radiation.
However, if water consumption varies greatly from season to season (e.g. if the system is used for drinking water and irrigation), the reference month will be the one with the lowest ratio between solar radiation and volume of water required.
- Solar radiation is expressed in peak sun hours (PSH). The daily volume of water divided by PSH is used to roughly define the hourly flow rate required and to compare it with the safe yield of the well. If the required flow rate is lower than the safe yield, solar pumping is possible. If it is higher, a more precise analysis will have to be carried out (e.g. using sizing software) to determine whether such a system is possible, whether a hybrid system should be opted for or whether a complementary water source is needed.
- In the case of a hybrid system, check the financial relevance compared with the conventional system by carrying out a life cycle cost analysis.



NOTE: There are various platforms that can be used to calculate solar radiation for a specific location and month. Some solar pumping system suppliers have also developed softwares that can be used to fully design a solar pumping project.
See references on page 7.

System sizing

STORAGE TANK

- The volume of the storage tank must comply with national guidelines. In the case of solar pumping, it should be kept in mind that the tank will be filled during the middle hours of the day, when consumption is low. To optimise the storage volume, compare the hourly pumping rate with the hourly consumption rate for the least favourable month of the year.
- The location of the tank depends on the type of project and the water distribution network to which it is connected. It must be high enough to supply the distribution network by gravity and, at the same time, be as close as possible to the water source to minimise the energy required from the pump. Often, compromises have to be made. For complex projects, different scenarios are evaluated using a sizing software.

CALCULATION OF THE TOTAL DYNAMIC HEAD (TDH), CHOICE OF PUMP

- The pump is placed in a full section of the borehole at least 1 to 2 metres below the dynamic level corresponding to the operating flow rate. If it is to be placed in a screened section, a sleeve must be provided.
- The total dynamic head is the height difference between the dynamic water level and the tank inlet. To this we must add linear pressure losses (due to friction in the pipes) and specific pressure losses (due to the various components).
- The pump is selected by comparing the system's operating point (required flow rate – TDH) with the pump's characteristic curve (i.e. the flow rate supplied as a function of the head). A pump is suitable if the operating point coincides with the curve and is also within the pump's maximum efficiency range (optimum operating point).
- Wherever possible, DC pumps should be preferred (longer life, more efficient, savings on the DC/AC converter).

SIZING AND LOCATION OF PHOTOVOLTAIC PANELS

- Photovoltaic panels should be located as close as possible to the water point to minimise cable losses and should be accessible for regular cleaning.
- The number and configuration (series and parallel) of the panels are determined by the energy required by the pump to bring the water to the reservoir. Although this calculation can be done manually, a sizing software is generally used.
- The majority of panels available on the market are mono- or polycrystalline. Particular emphasis should be placed on quality by checking certifications and authenticity.
- PV efficiency decreases with temperature. Leave space between and under the panels to allow air to circulate. In hot climates, it is advisable to compare technical specifications and prefer panels with the lowest temperature coefficient. The use of amorphous silicone modules may be useful if the average temperature is above 40°C.
- The panels should face the equator (towards south in the northern hemisphere and vice versa). The inclination should correspond to the latitude of the location, but at least 15° to optimise self-cleaning during rainfall. It is essential that the panels are not shaded (by nearby objects, vegetation or a row of panels in front).
- The choice of supporting structure depends on local conditions. In general, a distinction is made between mounting on the ground (resistant, easy to maintain but lost space and susceptible to theft or vandalism), on posts (sensitive to wind, less accessible, possibility of using space on the ground) or on an existing structure, e.g. a roof (use of existing space, less accessible, but limited by the geometry of the building).

CONTROL BOX AND PROTECTIVE ELEMENTS

- The control box should also be located close to the water point, in a protected, shaded and ventilated area (generally under the PV modules or in a small, dedicated room).
- DC switch between the solar panel and the inverter/control box (remember that the panels are always live during the day, even if the pump is not running).
- In addition, ensure the correct sizing of the pump power cable, that there is a surge protector, that there is dry-run protection, that the wellhead is protected, that there is a full-tank switch, that there is a lightning arrester and that the PV modules are earthed.

CHOICE OF ACCESSORIES

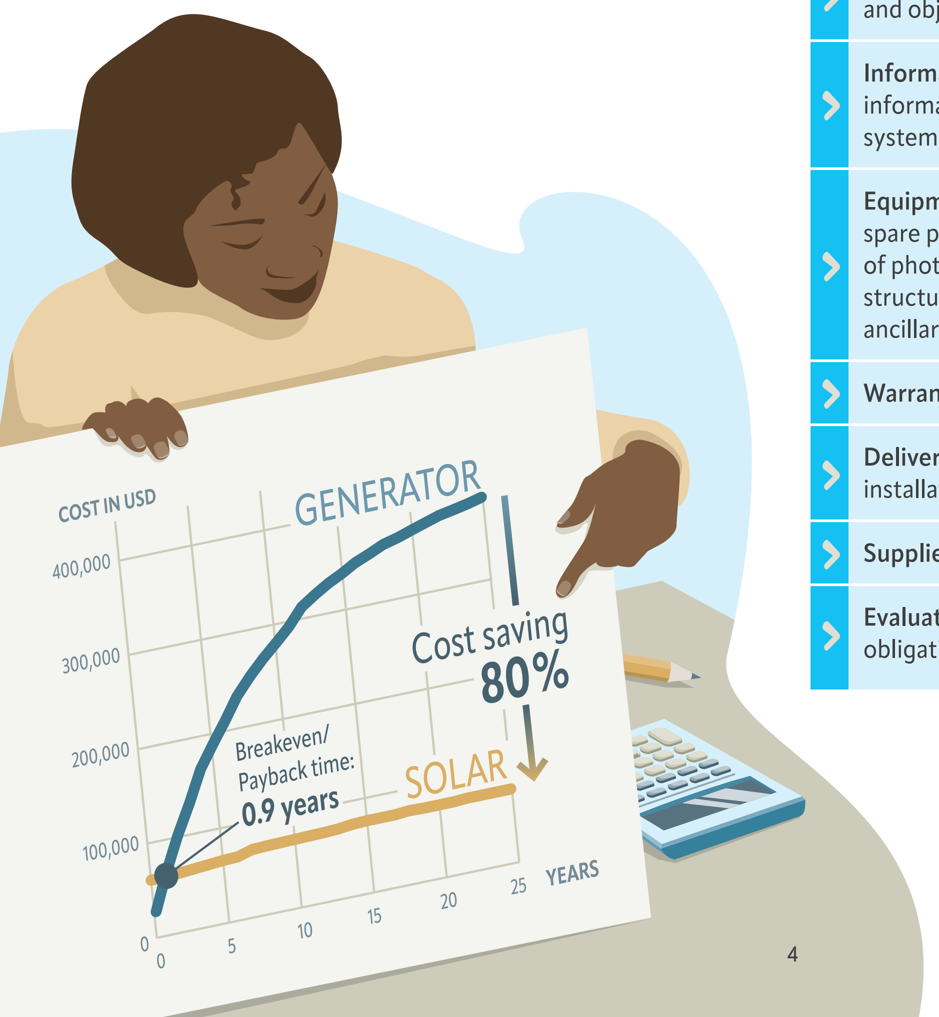
- Measuring the water level in the borehole: piezometric tube accessible from the wellhead or installation of a pressure sensor in the well.
- Flowmeter on the discharge line
- Solar radiation sensor
- Dosing pump (for chlorination)

And so on.

02 LIFE CYCLE COST ANALYSIS

Management of costs

- Draw up a list of costs:
  - **Investment costs**
    including acquisition, transport and installation
  - **Recurring costs**
    operating (including salaries), maintenance, refurbishment, equipment replacement
- Establish the analysis period. We use the element with the longest lifespan, i.e. PV, typically 25 years.
- Reduce future costs to today's value, i.e. apply the real interest rate of the country concerned.
- Compare the costs between the solar (or hybrid) system and the conventional (existing) system.



03 TENDERING PROCESS

Components quality

- Make an assessment in terms of performance, efficiency, reliability, compliance with certification standards, durability, solidity and viability.

Supplier qualification

- Assess the supplier's quality management system (e.g. ISO9000), reliability of delivery and deadlines, experience and reputation, technical capabilities and staff training, after-sales service and guarantees.

ELEMENTS OF THE TENDER DOCUMENTS (TECHNICAL PART)

- **General information:** location, project context and objectives
- **Information on the project:** scope, water demand, information on the water source, details of the system's operating procedures and configuration
- **Equipment specifications:** maintenance and spare parts requirements, ease of use, details of photovoltaic modules, details of supporting structures, pump and motor, control box, ancillary equipment and protection systems
- **Warranties, after-sales and maintenance services**
- **Deliverables:** delivery note, test certificates, installation and commissioning
- **Supplier qualification:** see above
- **Evaluation of the bid:** evaluation criteria, timetable, obligations, content of the submission file

04 INSTALLATION AND CONTROLS

NOTE: Experience shows that it is important to respect the order in which equipment is installed, even if careful planning has been carried out. This allows the project to be modified if there are any surprises.

1 Pump installation

- Professional splicing of the cable; on-site inspection (resistivity measurement and/or pump test in a submerged tank).
- Check pump specifications before installation.
- Install dry-run protection.
- Install accessories (e.g. pressure sensor).
- Make sure cables are attached to the discharge pipe and simultaneous installation of a cannula (for dipmeter).

2 Fitting the control box

- Position the control box close to the PVs and the well (to limit cable losses).
- Install the box in a protected, ventilated area.
- Install surge protectors and circuit breakers.

3 Installation of PV support structures and panels

- Check that the panels are from the same manufacturer and of the same model (no different modules).
- Ensure correct orientation and inclination.
- Measures to protect against theft.
- Tidy cabling, MC3 (or MC4) connectors; check parallel/serial arrangement of modules.
- Control earthing, lightning conductors, surge protectors.

4 Other items

- Tank
- Chlorinator
- Accessories

And so on

5 Commissioning checks

- In addition to the checks to be carried out when the various parts are installed, a commissioning and performance test must be carried out, together with a test report. The system can then be officially handed over.

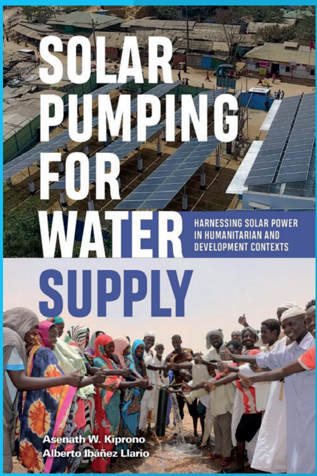
05
OPERATION AND MAINTENANCE

Effective O&M strategies

- Ensure that the system and its maintenance are correctly presented, and that operating staff are properly trained. Draw up operating sheets and checklists.
- Draw up a schedule of routine maintenance tasks (regular cleaning, leak checks, filling checks, free residual chlorine, etc.); these are generally carried out by the staff in charge of operation.
- Draw up a schedule for preventive maintenance (inspections and checks to ensure that the system is working properly), usually carried out by a specialist. Ensure that service agreements are made clear to the owners of the solar system (who to contact in the event of a fault).
- Troubleshooting and repair (specialist).

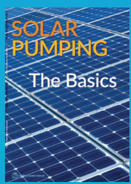
NOTE: It is often preferable to arrange a maintenance contract/service with the company responsible for the installation.

REFERENCES

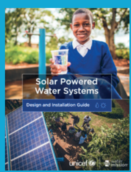


Literature

Solar pumping for water supply. Harnessing solar power in humanitarian and development contexts
by W.Kiprono and A.I.Llario
> *https://bit.ly/42B9Oax*



Solar pumping: the basics
World Bank
> *https://bit.ly/3Cuq4zA*



Solar powered water systems: design and installation guide
Water Mission and UNICEF
> *https://bit.ly/4aCVrVg*

Solar pumping: electrical design and installation of solar pumps guidelines
Action Against Hunger
> *https://bit.ly/40yWAbX*

Websites dedicated to the subject

The solar Hub: > *https://thesolarhub.org*

Global Water Center: > *https://globalwatercenter.org/learn-with-us*

Solar irradiance

Solargis: > *https://solargis.com/resources/free-maps-and-gis-data*

Global solar atlas: > *www.globalsolaratlas.info/map*

NASA power Data Viewer: > *https://power.larc.nasa.gov/data-access-viewer*

European Union photovoltaic geographical information system:
> *https://re.jrc.ec.europa.eu/pvg_tools/en/tools.html*

Pump sizing

Lorentz (solar system sizing software, for customers): > *www.lorentz.de*

Grundfos (sizing and selection of online pumps):
> *https://product-selection.grundfos.com/size-page?sQcid=2414899245*

Franklin: > *https://franklin.config.intelliquip.com/config/franklin/cos*

Certification of photovoltaic panels

TÜV Rheinland: > *www.certipedia.com*

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hands4health.dev

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