University of Strathclyde Engineering

Malawi Community Energy Sustainability Extension

Market Assessment Training

20th – 22nd January 2016

Lilongwe

Community Energy Malawi

Solar Pumping

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Contents

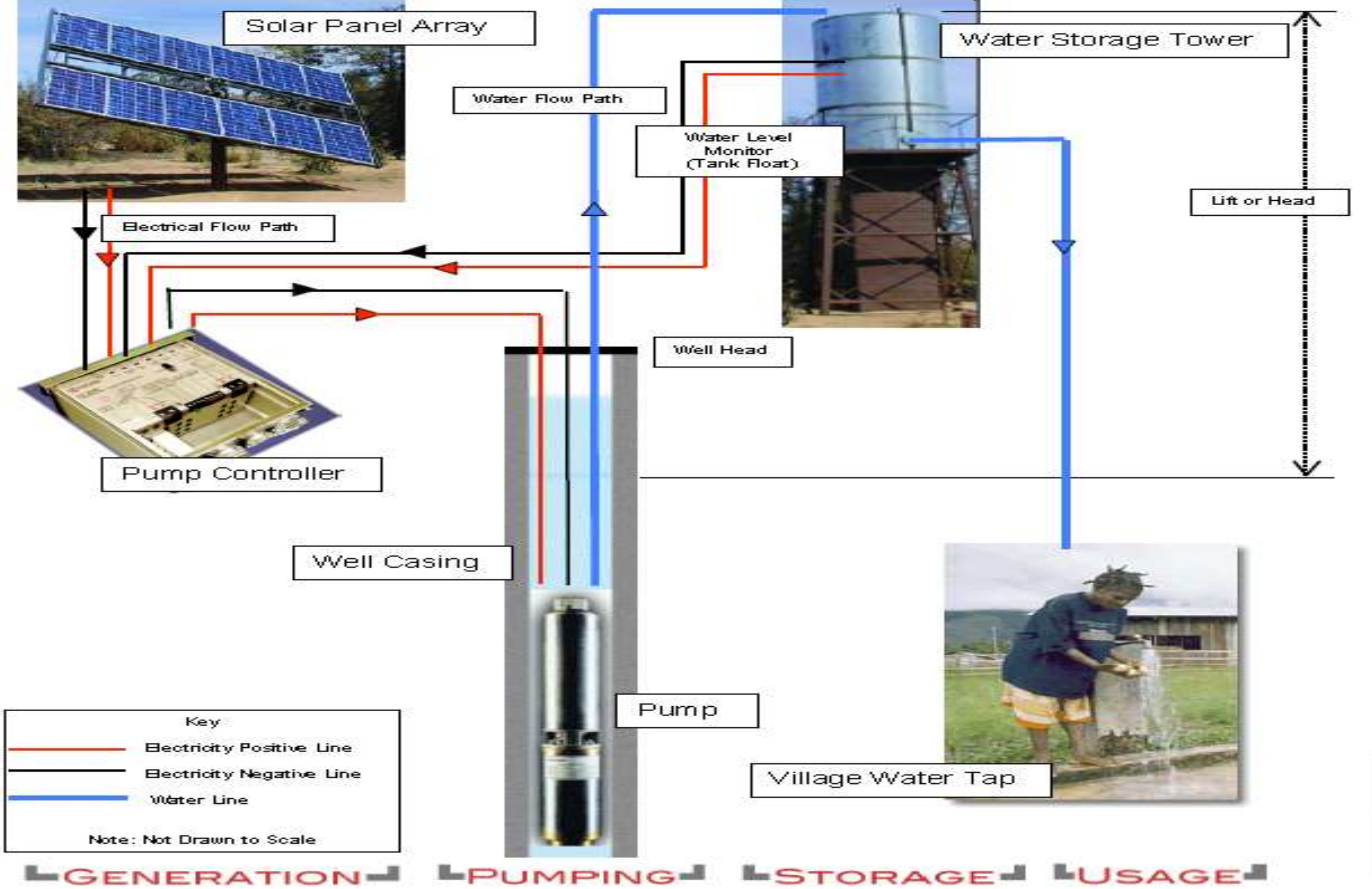
- How do you pump water?
- System Overview
- Parameters to Consider
- Examples
- Output for this project

Options for Pumping Water

Technology	Advantages	Constraints, comments
Human Pumping	-Very Low cost -No fuel needed -Low maintenance	- Very time and labor consuming - Limited in depth & flow (power required)
Gravity Fed or Ram Pump	-Low cost -Simple to install and use -Easy maintenance -No fuel needed – 24 x 7 operation	**Gravity:** Needs a clean spring above located above the town **Ram Pump**:- Need appropriate site (falling water at a lower level, to be moved to a higher elevation) -Draws from stream water or spring
Diesel Generator	-Moderate initial cost -Easy to install	-Frequent maintenance., expertise required --Fuel often expensive, supply intermittent -Noise, dirt, fumes -Lifetime (20 yr.) fuel costs very high
Solar Pumping System (SPS)	-Easy to install -Reliable -Low Maintenance, -No fuel needed, Clean	Solar energy can vary seasonally Highest initial cost Lower output in cloudy weather
Wind Turbine	-Lower initial costs than SPS -Long life -Effective at windy sites -Clean -No fuel needed	-High maintenance needs -Expensive repair -Parts difficult to find -Wind can vary seasonally -Lower output in calmer winds

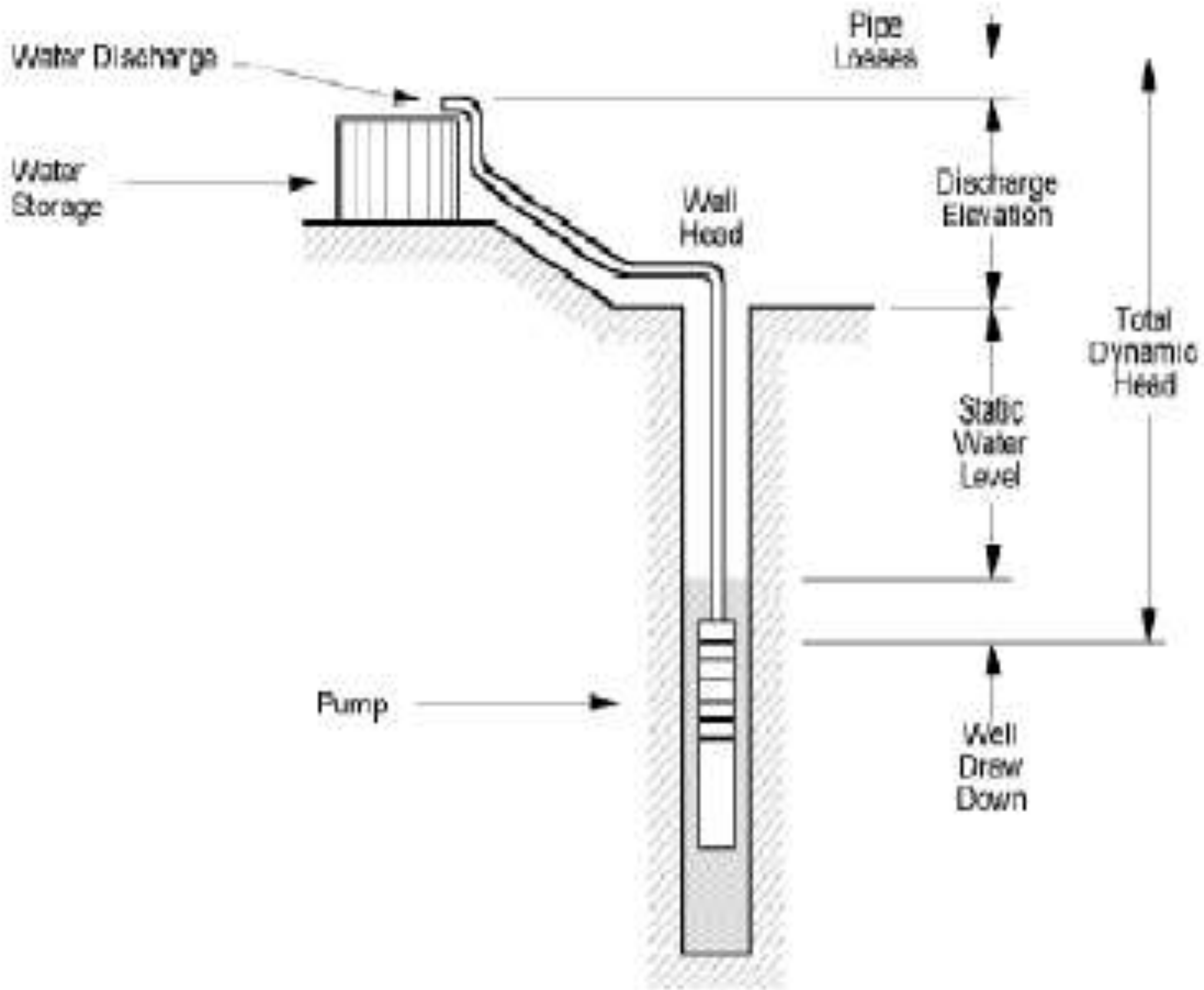
Solar PV for Pumping Water

- Cost effective for low volume/ low head systems. I.e. low energy systems. (up to about 2kWpk)
- Good in low latitudes.
- No batteries required. Water gets pumped when the sun shines and is stored till it is required.
- Frees people (especially women and children) to get on with more useful, fulfilling work.



Solar Panel Array
Water Storage Tower
Water Flow Path
Water Level Monitor (Tank Float)
Lift or Head
Electrical Flow Path
Well Head
Pump Controller
Well Casing
Pump
Village Water Tap
Key
Electricity Positive Line
Electricity Negative Line
Water Line
Note: Not Drawn to Scale
GENERATION
PUMPING
STORAGE
USAGE

System Sizing (Inputs)



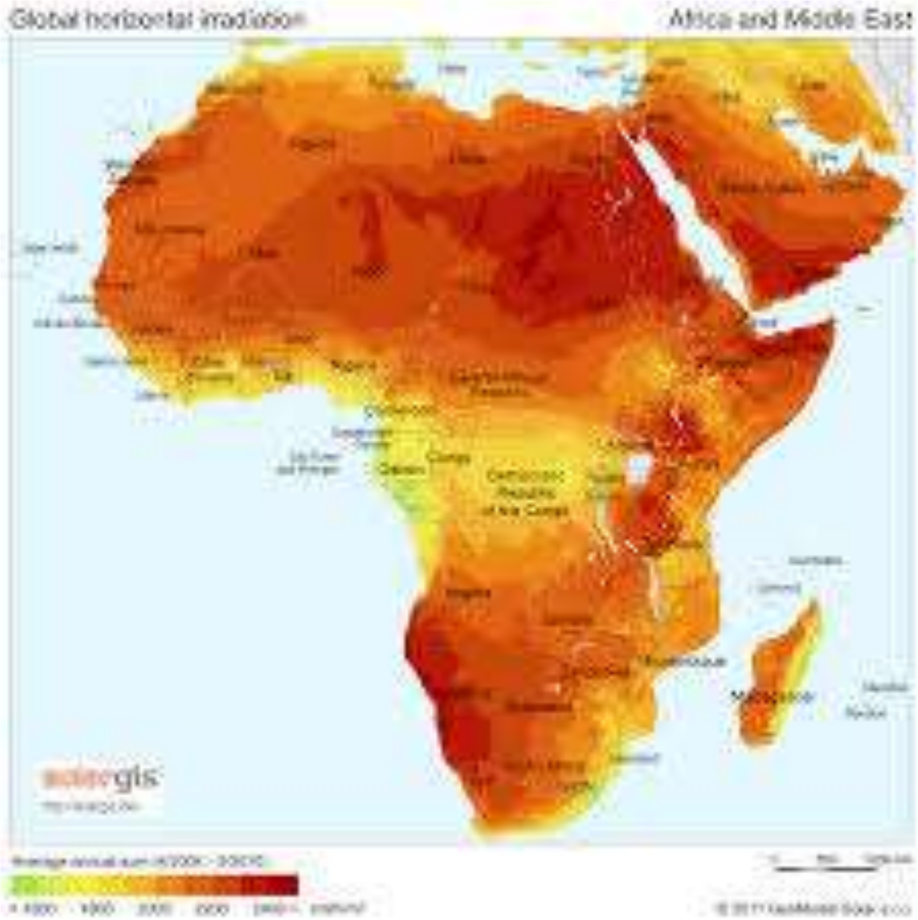
Requirements:

- Static Lift (m)
- Flow (m^3/day)

Resources:

- Irradiation (kWh/m^2-day)
- Water well (bore hole)

Solar Irradiation



- PVGIS
- IRENA

Water Use

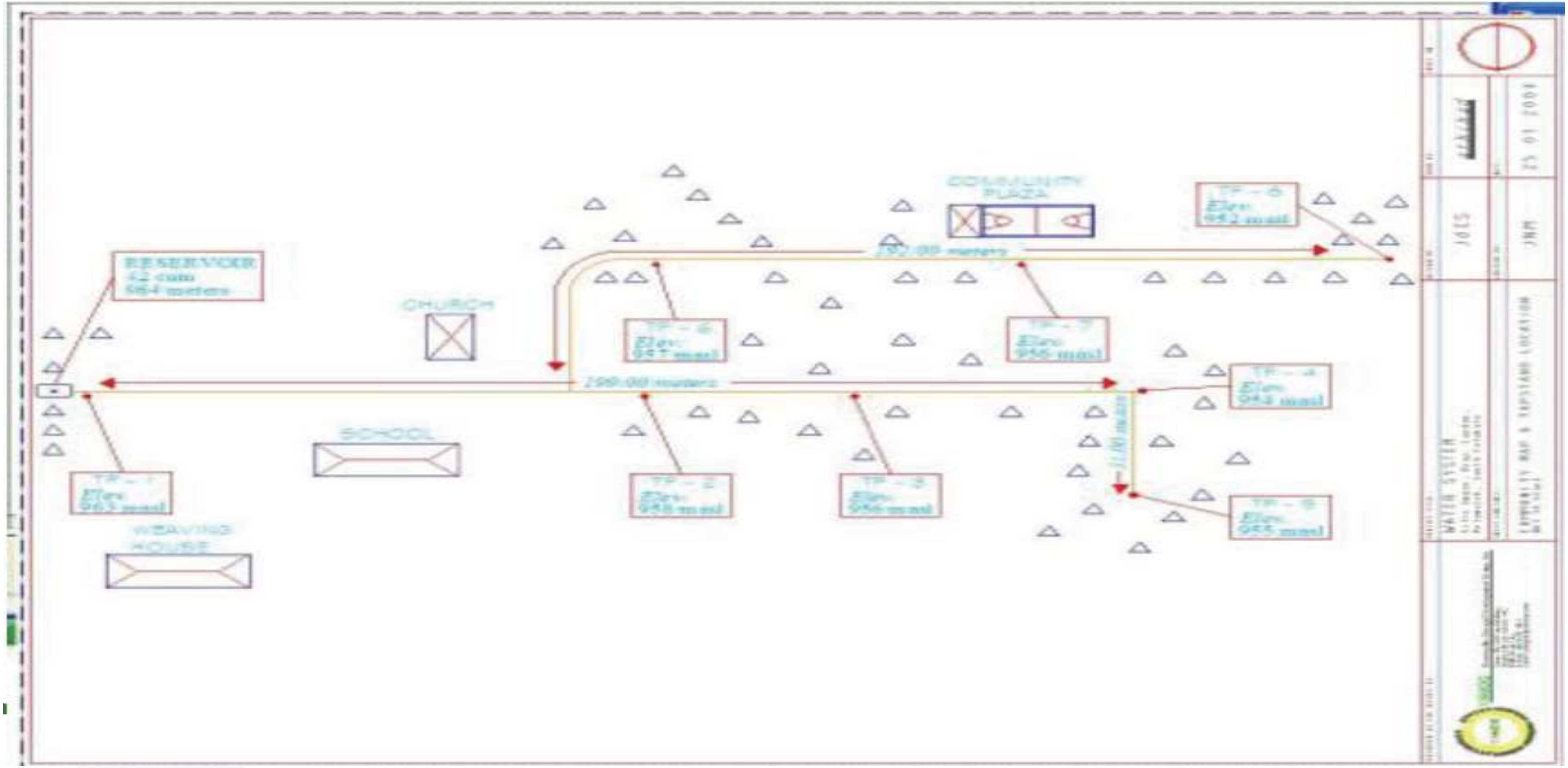
Users	Guideline liter/day	Quantity	Total m^3/day
People	**40+**	**500**	**20**
Dairy cow	90		
Horse	50		
Pig	17		
Sheep / Goat	6		
Chicken	.15		

Notes:

1) a proper population survey is needed to see what the water will be used for, if it is a straight replacement for current uses, or if new uses are expected.

2) small plants & trees, and animals may be provided gray water.

Map the village



Example System

- 600Wp modules
- Mono Pump
- Mono Inverter
- Cables
- Support frame

Equipment cost : £ 4,500 EXW UK

Sea freight £ 250
Installation £ 250

Tracking water pump

Case Study: Ensol Tanzania

Project description

The project was implemented in 2012 – 13. All **11 villages** in Mtwara Rural, a region in South of Tanzania, were supplied with a solar water pumping system capable of supplying a maximum of **50,000 litres of tap** *water* per day. The minimum water **pumping head was 100 m** and in some villages, where water was transported from the source to the village over a distance of 1.9 km. **A water committee** in each village is responsible for collecting a small contribution from residents to sustain the project.

Project financing and costs

The **340.000 USD** project was financed by the European Union and administered by African Medical and Research Foundation (AMREF). Procurement was conducted through open competitive tendering.

Policy and regulatory framework

Since 2005, most of renewable energy equipment can be imported into Tanzania tax-free. This decision has impacted the spread, usage and application of renewable energy technologies in Tanzania.

Project outcome

Residents of the eight villages are still enjoying tap water three years after the completion of the project.
As a result of the success of the project, the government has notified all district councils in Tanzania to put in place plans to ensure that all diesel water pumps in Tanzania are replaced with solar pumps.

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- Stationary OR Tracking Arrays

Output for this Project

- An application for solar PV system for solar pumping has been identified in the **Dowa** region
- Market assessment completed to find out
  - the cost of implementation,
  - who will be the users of the system,
  - how it will be financed
  - who will complete the maintenance of the system.
- The market assessment can then be used as a template to be carried out in other areas for similar projects incorporating solar pumping for potable water.

Feasibility Study

GREEN EMPOWERMENT

Solar Pumping Systems (SPS)
Introductory and Feasibility Guide

Community Feasibility
- Checklist

Technical Feasibility
- Resources
- Needs
- System Sizing

Project Design
- Community
- Technical
- Costs

Maintenance and Evaluation

Typical Communities Using a SPS

Currently, families must walk a good distance to obtain potable drinking water. Existing wells are too shallow or deeper wells would not work with typical rope pump mechanisms.

The people in the community work well together, with no divisive groups. The proposed project would provide services to ALL community members with no discrimination. There is good local leadership and social justice values are high.

The community is able to come together with a group representative, and organize to build, manage, and collect usage fees.

Water is used for drinking, day-to-day uses and perhaps animal watering. While large-scale applications like crop irrigation are generally not supported by an SPS, drip irrigation can be. Not intended to bring indoor plumbing or drastic changes in standard-of-living.

The site has reliable solar resources and relatively expensive, inaccessible, or inefficient alternatives. For example, fuel costs and maintenance for a diesel generator are prohibitive.

Questions and Discussion

3 Increasing PV sales by supporting innovative solutions for water supply

3.1 Case Study – Grundfos Lifelink

Background

Over the past two decades, a remarkable number of 2.3 billion people have gained access to safe water. However, there remain around 800 million people who still depend on water from unsafe sources. Many of these people are living in off-grid areas of sub-Saharan Africa (United Nations, 2014). The notorious unsustainability of rural water supply infrastructure in Africa makes it a kind of Sisyphus work to further reduce that number. Against this backdrop, Grundfos has developed a solution which combines proven pump technology, PV panels and an automatic water dispenser with revenue collection system. The solution termed Grundfos Lifelink addresses the sustainability problems in water supply for low income communities in the developing countries.

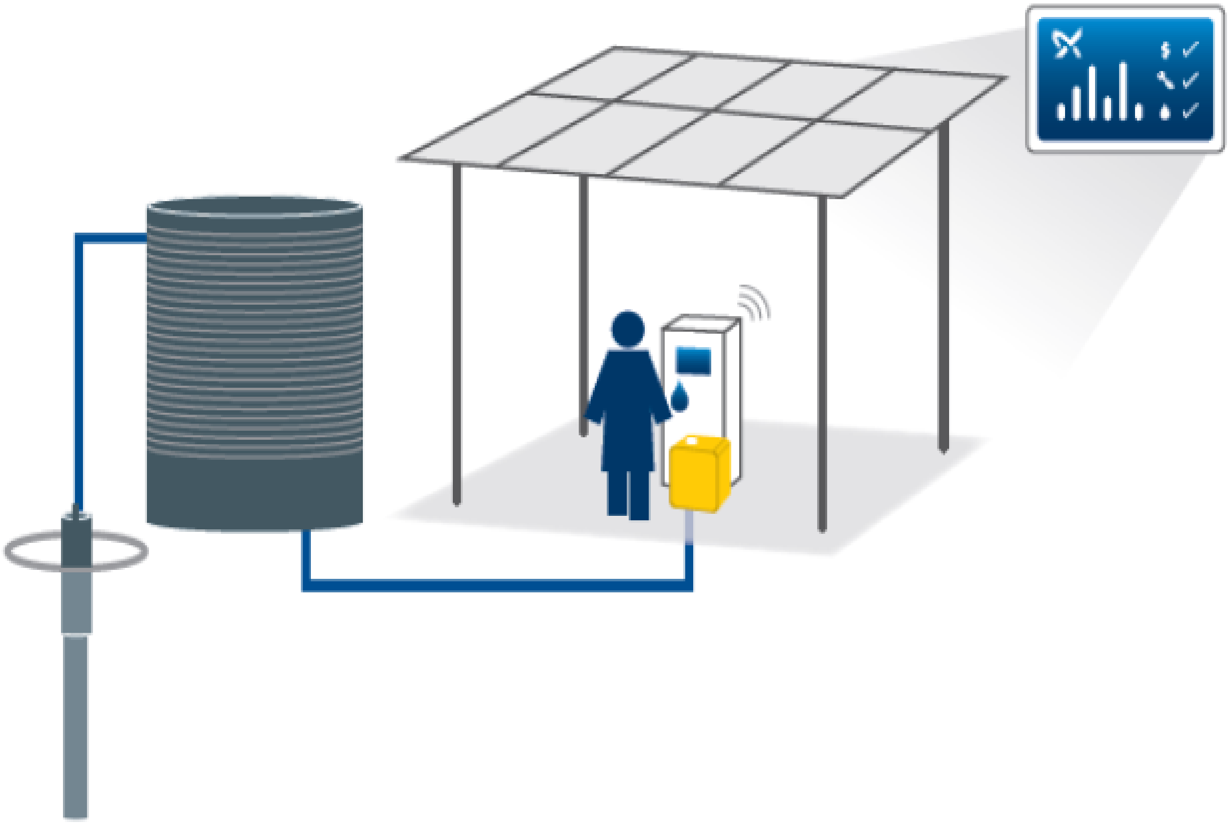
HOW DOES IT WORK?

The Technology

Grundfos Lifelink solutions can be designed to match small or large water schemes in both rural and urban areas. The foundation of each Lifelink system is the automatic water dispenser unit with an integrated system for revenue collection and water management.

For the 40 demonstration projects in Kenya, the Lifelink system consists of a submersible pump which is operated by PV panels. Safe water is pumped from a borehole into an overhead tank. System sizes range from 50Wp to 9.2kWp with pumping heads up to 200m.

The PV panels also power the dispenser unit where consumers can tap water using a water card with water credits.



Professional Service and Support

The water revenues collected from the Lifelink systems can be used to cover the costs of professional service and maintenance of the water projects. A network of local Grundfos service partners with the required spare parts in stock will support the water service providers in keeping the water systems up and running. Various service options, from service contracts to training sessions are available to the water service companies, NGOs, or community-based associations. The common feature is an online water management platform which allows the remote monitoring of each system. Each dispenser unit feeds the platform with operational data via the GSM network. A system failure can immediately be detected and repaired by a service team. The actual water consumption at each Lifelink installation can also be followed via the same system.

PPP BASED BUSINESS MODEL IN KENYA

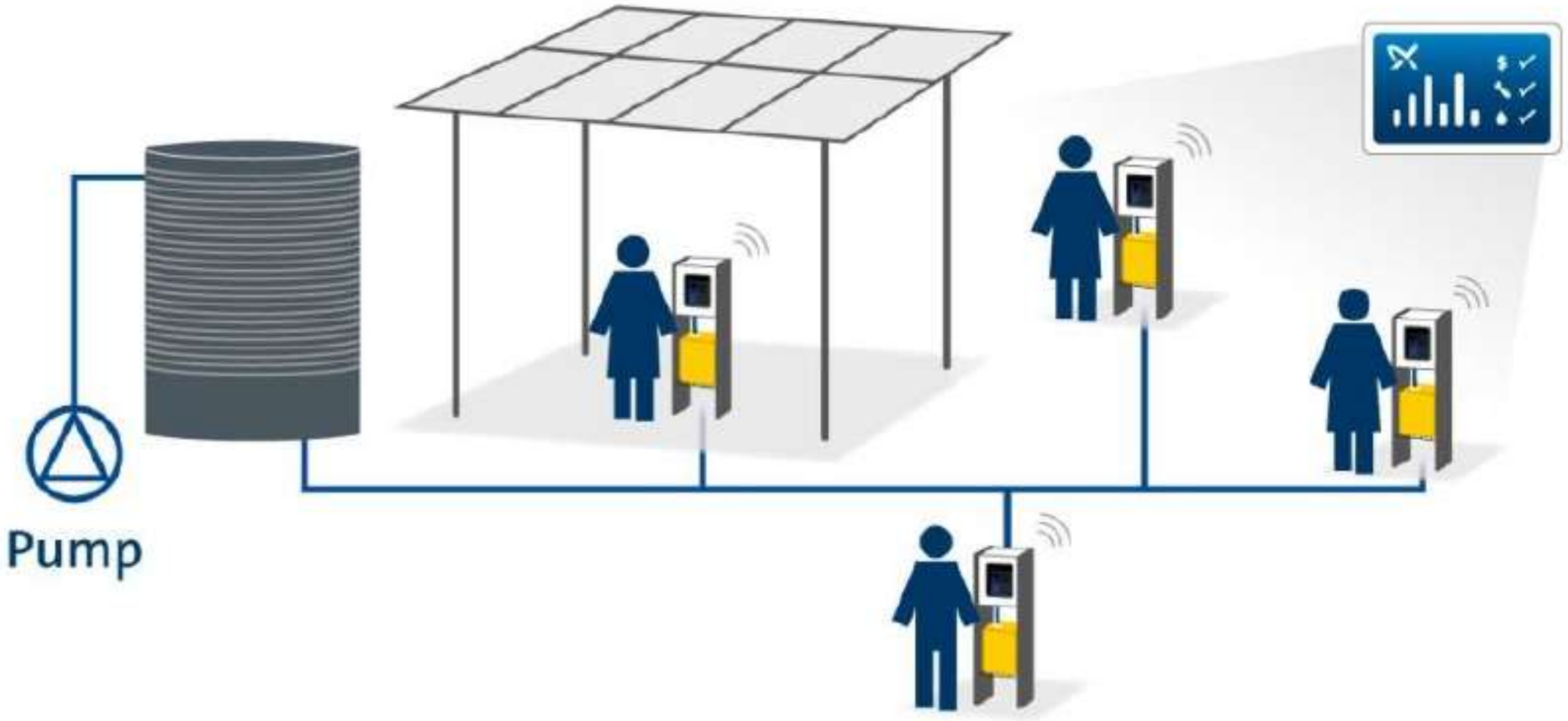
Since 2009, Grundfos has implemented more than 40 demonstration projects in Kenya based on the Lifelink solution and in collaboration with partners across various sectors. The results demonstrate a new model for financially, self-sustaining water supply projects where user fees pay for service contracts with the local service provider.

Under this business model based on a public private partnership approach, the public partner (donor organization) has funded the initial investment on a grant basis and provided community development and training where needed. The private partner (Grundfos in Kenya) has installed the systems and provides monitoring and maintenance services on a commercial basis. The demonstration projects in Kenya are implemented in the arid and semi-arid regions of Kenya, where surface water is scarce most of the year. They provide a reliable access to safe water for approximately 100’000 people.

Outlook

Having proven the concept of the Lifelink solutions, Grundfos is now paving the way for water service providers in prioritized sub-Saharan African countries to invest in the technology. To lower the investment cost, Grundfos has developed a new dispenser unit which is competitively priced. The new dispenser called AQtap will be available from June 2015. The significant cost reduction means that commercial business models will become increasingly feasible in the future. It also means that more dispenser units can be installed bringing water closer to the people and thus increasing the revenues from water sales.

Combining multiple dispenser units in mini grids requires the setting up of additional PV generation capacity either at small single points or larger PV arrays feeding a mini electricity grid. As we say, "the appetite comes with the eating", the installation of PV powered water supplies is triggering demand for additional electricity services. In Tanzania, Grundfos is already involved in a pilot project where the PV array has been over-designed to also feed a mini grid. This will give momentum to the development of new innovative business models in the future.



CEM Market Assessment Training January 2015

Motor pump/ Configuration	Output (m^3.day) @ 5kWhm/cu.m/ day insolation	Head (m)	Solar Array (Wp)	System Price US$ FOB
Submerged borehole motor pump	40 25	20 20	1200 800	7000-8000 6000-7000
Surface motor/ submerged pump	60	7	840	5000-6000
Reciprocating positive displacement pump	6	100	1200	7500-9000
Floating motor/pumpset	100 10	3 3	530 85	4000 2000
Surface suction pump	40	4	350	3000

Measuring Head

- Lift: The water needs to be elevated from its (worse seasonal) dynamic level in the well or spring to the point of delivery into the tank.
- Head: in addition, there is a resistance due to friction in the pipes, fittings, etc. This is usually converted in "equivalent length of pipe"
- The total of Lift and friction head is the Total Dynamic Head **(TDH)**
- Field measurement techniques and friction losses are beyond the scope of this workshop but very important

Request for Quote: what to ask

- Provide basic characteristics: depth, drawdown, maxi flow rate, lift (TDH estimate), target daily flow, geographical location.
- Ask for performance forecast for the site (simulation)
- Be ready to adjust description as field info may be adjusted
- Request itemized quote from local & overseas vendors and see what could be procured locally and at what cost.
- Enquire about shipment duration & cost alternatives

Separately, from local resource:
Find out about possible import taxes, brokerage fees, etc.

Sizing solar pumps

Sizing solar pumps

The hydraulic energy required (kWh/day)

= volume required (m^3/day) x head (m) x water density x gravity / (3.6×10^6)

= 0.002725 x volume (m^3/day) x head (m)

The solar array power required (kWp) =

$$\frac{\text{Hydraulic energy required (kWh/day)}}{\text{Av. daily solar irradiation (kWh/m}^2\text{/day} \times F \times E)}$$

where F = array mismatch factor = 0.85 on average

and E = daily subsystem efficiency = 0.25 - 0.40 typically