Solar pump technology: programming insights for sustainable rural water supply

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Abstract/Summary

Over the past few years, UNICEF Country Offices and their partners have demonstrated an strong interest in implementing solar powered water systems schemes at the community level. A total of 34 countries are currently using solar pump technology in their water supply programmes. Demand from beneficiaries is high, due to minimal day-to-day running costs and the relative durability of the systems. As the price of solar panels decreases and the positive contribution of solar powered systems becomes more evident, it has been vital to take stock of the progress so far and provide recommendations for improved programme implementation and scale-up. The solar pump assessment was carried out in 4 countries (Nigeria, Mauritania, Uganda and Myanmar) from July 2015 – March 2016. The four selected countries have have piloted the use of solar pump technology over the past few years with varying degrees of success. Contrary to popular belief, it was found that overall the technology itself is highly sustainable in the longterm. However, significant improvements need to be made to the professionalisation of the sector, including borehole siting and installation, increasing the availability of spare parts and the collection of user fees at the household level.

Introduction

UNICEF first began piloting solar pumps in off-grid areas more than 25 years ago. Since then, the technology has evolved and the reliability and maintenance requirements have improved significantly. Costs have also decreased as more technology options become available on the market. A total of 34 UNICEF country offices are now using solar pumps in their WASH programmes. The majority of pumps so far have been installed in rural communities, schools and health care centres. Most of the systems studied were small in size (less than 2,000 people), with an average of 30-50 systems installed per country so far.

Solar pumps have close to zero running costs, unlike motorised pumps, which are noisy, polluting and expensive to run. Even though the initial investment for solar pumps is still on average around 20% higher than for motorised systems, solar pumps are becoming more competitive cost-wise with motorised-only pumps where strong market competition exists (Khan 2013). Hossain et al (2015) found that the cost benefit ratio of solar pumps (1.91) was significantly higher than diesel-operated pumps (1.31) when looking at investment beyond the initial five year period. Chandel (2015) similarly found that the investment payback for solar pumping systems was around 4–6 years.

As solar pumping systems increase in polularity with Governments, beneficiaries and donors, it has become vital to take stock of the progress made so far in order to address the challenges and give guidance for improved implementation and scale-up.

Description of the Case Study – Approach or technology

The solar pump study was carried out in Nigeria, Mauritania, Uganda and Myanmar from July 2015 – March 2016. The four selected countries have piloted the use of solar pump technology over the past few years with varying degrees of success.

The assessment looks at the effectiveness and sustainability of solar pump technology, particularly in regards to the programming surrounding it. The study was carried out in collaboration with local partners (including Government, NGOs and private sector), WASH Committees and beneficiaries. Assessments were carried out through direct observation in 35 communities (6-10 per country) which had been installed anywhere from 6 months to 10 years ago. In Mauritania, Nigeria and Uganda, water was distributed largely via tap stands, in Mynamar, small piped systems were used. Additionally, more than 300 individuals also took part in focus group discussions and key informant interviews which took place at the community, district and national levels.

Main results and lessons learnt

The overall findings of the study suggest that the technology itself has significant potential, particularly in communities where sunlight is consistent year-round and where water depth is less than 150 metres (commonly the maximum pumping depth. In communities with low water depths, or in those communities where water demand was very high (due to extrememly large numbers of livestock), and not spaced throughout the day, some solar systems experienced challenges. In these situations, hybrid solar pumps (which are also supported by a back-up mechianised pump) should be considered.

The majority of solar pump systems visited (64%) had experienced no major malfunctions since they were first installed. For those that had experienced issues, they tended to be relatively minor in nature (mostly relating to wiring, invertors and controllers). Automated systems (with float switches etc.) seemed to perform better than those which were managed manually. This relatively high functionality rate was in contrast to the handpumps and motorised pumps used in the same regions, which reportedly broke down 2-3 times a year on average.

Most communities reported very good yields, with the exception being on days with extremely heavy cloud cover (ranging from 2-7 days a year across the four countries) or during the dry season when demand was extremely high. Even though yield was reportedly lower during the rainy season, in most communities this was not a significant issue as it coincided with a reduced demand (compared to the dry season) and rainwater harvesting was often being used as a backup. Just 6% of communities of the communities surveyed stated they had year-round problems obtaining sufficient water.

For those systems which reported issues, the most significant challenges can be divided into five main categories;

i) Borehole siting and construction

The most common severe problems experienced could largely be attributed to poor borehole siting. Several of the water points visited had lower yields than expected or became dry at certain times of the year, leading to the burnout of key pump components. To save money, it was found that partners would often favour the use of existing boreholes without sufficient testing. The presumable issue of "silting-up" was also a problem in several cases due to inadequate positioning of screens, inappropriate gravel packs and lack of geotextiles.

ii) System dimensioning

The majority of UNICEF programmes use Grundfos SQ Flex and Lorenz PS pump models based on their proven durability, output and cost effectiveness in the long-term. All Government, NGO and private sector partners interviewed named Grundfos and Lorentz as the most desirable brands. Mono and Franklin were also rated highly. Unfortunately, the dimensioning of systems was not always found to be optimal – particularly where materials were being procured in bulk and a "cookie-cutter approach" was seemingly being favoured by some partners and didn't always take into account key factors such as borehole yield, sun hours, the needs of livestock, shading/seasonal fluctuation, peak demand times and population growth over time.

iii) Spare parts supply chain

In Mauritania and Myanmar in particular, official spare parts were difficult to access and expensive, largely because key brands did not yet have a strong enough presence. In Nigeria and Mauritania there were also complaints of fake spare parts flooding the market. In Myanmar and Mauritania especially, spare parts would usually have to be shipped from the capital – which significantly extended the time it took to repair systems. Taxes were also extremely high on solar pump products, making them less competitive with motorised systems. In Nigeria and Uganda, markets were more extensive, so availability or products (and relative cost) were less of a challenge. Quality control is left up to the contractors/partners who procure spare parts.

iv) Availability of trained technicians and pump mechanics

In most of the countries visited, there was a significant need to improve technical capacities of Government, private sector and community partners. At present there is a heavy reliance on a small number of qualified technicians, who often reside out of state. Demand for their services is high, meaning that the fixing of minor repairs (which could be easily done at the local level) is both expensive and slow. It is vital that more partners (both public and private) complete hands-on training.

v) Collection and management of user fees

As the potential costs of repairing a major solar pumps malfunction are high (compared to handpumps for example), it is vital that the community or service provider collect a sufficient amount of user fees to ensure the sustainability and longevity of the system. For UNICEF-supported programmes, this price is determined by individual WASH Committees in consultation with households. Average costs per household varied with an average family in Myanmar paying $1.50 a month to around $4.50 a month in Uganda. The majority of households found this to be affordable.

Ensuring the absolute poorest were reached was a challenge. In all of the countries surveyed, communities would often make a provision for the poorest (in the form of free or discounted water) – but this was not always the case.

In most cases, collected user fees were managed by WASH Committees and held in a Community WASH Fund. In the best cases, these funds were held in official bank account and payment log books were maintained by WASH Committees.

Households were provided with receipts every time they made a payment.

Where this system worked well (for example in Myanmar) communities had amassed an average of $500-3000. This was sufficient to cover most repairs. Where surplus funds existed, money was also often being used by communities to support other community-based initiatives or provide low-interest loans. Where WASH Committee capacity was lacking and fees were not being effectively collected, community WASH funds were often insufficient, meaning the community became heavily reliant on external support if the pump malfunctioned.

Conclusions and Recommendations

Results from the UNICEF Solar Pump Evaluation have shown that the technology itself appears to be highly sustainable in locations where sunlight is plentiful and water levels do not exceed depths of 150 metres. The majority of systems had rarely experienced any problems and were an effective method of providing safe water, often in piped form, to thousands of people. The systems were popular with communities, Government and private sector parners due to their very low day-to-day running costs and long-term durability. In countries such as Nigeria, with a competitive market, initial investment costs were highly competitive with motorised systems.

Compared with other pump types (handpumps and motorised), solar pump breakdowns seem to be far less frequent.
All minor issues were easily fixed, where spare part chains and trained technicians were readily available. Major issues, could almost always be prevented by improved borehole siting, construction and installation.

The successful collection of user fees by communities, to support a solar pump maintenance fund varied in success between communities and countries. It should be noted that all these listed issues are not specific to solar pumps – similar issues are also experienced with other pump types and the general management of water services.

In conclusion, solar pump technology provides an excellent opportunity to support the drive for universal basic water, particularly for those living in the most isolated rural locations - *if* the quality of programming surrounding the technology is effective. More investment needs to be made in improving both public and private sector capacity to install and manage systems, improve the supply of quality spare parts and the professionalisation of the drilling sector as a whole.

Recommendations

1. Improve the professionalization of borehole siting, construction and development

- It is vital that borehole siting, construction, "development" (following construction) and water quality testing is carried out in a professional manner. Working with the Government to ensure improved selection and training of contractors, in addition to ensuring betterdrilling standards and holding them accountable for poor work is vital..
- Ensuring legally-binding performance-based contracts which focus on long-term results is one way of ensuring the accountability of the contractor

2. Improve system dimensioning

- To avert water shortages, it is vital that the total water needs of the population during peak demand times is accurately calculated <u>prior</u> to installation. Pump capacity, storage and solar panels must then be adapted accordingly. Ensuring sufficient storage (for at least 1-2 days) is vital – in order to providing a buffer during system downtime and days with heavy rainfall.
- Where demand is exceptionally high, a back-up generator (hybrid system) could be used or cheaper, unprotected sources could be developed for use by livestock.
- When upgrading handpump boreholes to solar systems, it is vital that a thorough hydrogeological survey be carried out in order to assess borehole viability and prevent excessive groundwater depletion.

3. Strengthen the solar pump market and spare parts supply chain

- Government monitoring and licensing of registered suppliers must be improved in order to ensure counterfeit parts do not flood the market. Penalties must be established for those selling counterfeit and sub-standard products.

  In Myanmar and Mauritania, import taxes were extremely high on solar pump products. Adocating the Government to reduce such taxes is vital if solar pump technology is to become more competitive.

4. Increase the number and capacity of technicians and pump mechanics

- It is vital that all relevant partners complete hands-on training. Major solar pump brands should also play a lead role to play here in training and certifying private sector partners in particular.
- WASH Committee members and Community Operators would benefit from additional and regularised solar pump training (particularly in regards to day to day maintenance).

5. Strengthen the collection and management of user fees at the community level

- Ensuring sufficient training is provided to WASH Committees, particularly in terms of financial management is vital. Establishing key accountabilities of WASH Committees, households, public and private sector is also vital (in the form of a contract) at the start of the project.
- Ensuring WASH funds are held in an official bank account with statements and amounts collected per month regularly and transparently being shared with community members is vital in order to build trust and encourage the future payment of user fees.
- In Mynamar, communities contributed a percentage of the initial material and installation costs. This was found to be great way of ensuring ownership and the collection of user fees (to safeguard their investment). This is something which should be encouraged in other programmes also.

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