Report on the financial barriers to the uptake of solar powered borehole pumps within rural Kenyan communities, and how these can be addressed.

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Water kiosks in Kakuli (top) and Kalawa (bottom), Makueni County, Kenya.

1. Executive Summary

This study assessed the financial barriers to the uptake of solar powered borehole pumps within communities in rural Kenya in order to provide recommendations to assist with the Kenya Integrated Water, Sanitation and Hygiene (KIWASH) Project Outputs 2 and 5[1].

Prior to conducting primary research, background literature was consulted to justify the need for the study and to provide context to the area of investigation (see Annex A). Discussions with six organisations were held which included suppliers (Davis and Shirtliff & Grundfos), a finance provider (Sidian Bank), consultants (African Solar Designs & EED Advisory) and Winrock which is part of the USAID funded Kenya Smallholder Solar Irrigation Project. In addition, 6 community projects were visited, 3 in the Western Counties of Siaya and Kisumu, one in central Kiambu and two in the Eastern County of Makueni.

It was found that the sustainability of current solar borehole community projects is being hindered by several issues surrounding their management, revenue collection and maintenance. These issues must be addressed before financial organisations will be willing to provide loans for potential future projects. This finance is needed to reduce current dependence on donors for the funding of projects. In addition, future projects are impeded by a lack of awareness from both communities and lenders about the potential of solar borehole pumping to improve lives, be sustainable, reduce the cost of water and generate sustainable revenue that can be used to repay loans. Partnerships between banks and communities are currently insufficient as a lack of trust and ability to meet repayment terms is resulting in a lack of lending agreements. This needs to be improved through the involvement of intermediaries such as KIWASH and county governments who can assist communities to become capable of repaying loans and to build up a sufficient level of trust within banks in order to make finance truly accessible to rural communities for the purposes of solar powered boreholes.

The identification of issues that are preventing current projects from being sustainable and preventing potential future projects from accessing finance enabled the formation of several recommendations that can be implemented by KIWASH, to make strides towards more independent and financially sustainable community water projects. These are summarised as follows:

Issues: Sustaining Current Projects

1. Improve the management of current projects
2. Make revenue collection methods more efficient and transparent
3. Educate communities to increase their willingness to pay for safe water
4. Provide training on basic maintenance

[1] Output 2: Sustained Access to Financing/Credit for WASH increased, Output 5: Environmental Sustainability of WASH services increased

Issues: Accessing

5. Use established, successful projects (once current issues have been addressed) to raise awareness and trust of banks and rural communities and promote lending by banks in order to finance projects
6. Identify communities that have the capacity to install and operate successful solar borehole projects
7. Explore the potential for partnership with Sidian Bank, and other financial institutions, if appropriate
8. Partner with county governments to encourage WSPs to use the technology at a larger scale
9. Create a management package that can be used to educate, organise and empower new PMCs to run successful projects
10. Enabling policy and legal environment

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List of Acronyms

DCA – Development Credit Authority
KES – Kenyan Shilling
KIWASH – Kenya Integrated Water, Sanitation and Hygiene
KSSI – Kenya Smallholder Solar Irrigation
MFI – Micro Finance Institution
O&M – Operation and Maintenance
PMC – Project Management Committee
SOW – Scheme of Work
UN – United Nations
USAID – United States Agency for International Development
USD – United States Dollar
WASH – Water, Sanitation and Hygiene
WHO – World Health Organisation
WSB – Water Service Board
WSP – Water Service Provider

1. Introduction

The KIWASH project aims to help more than 1,000,000 people across nine Kenyan counties access improved WASH services by 2020, increasing access to improved water by 1.0 percent per year above the current trend. Solar powered community boreholes present a feasible way for rural communities to access improved water in a manner that can improve environmental and financial sustainability. The high initial cost of solar arrays, elevated storage tanks and their associated pumps has so far prevented the wide spread adoption of this technology in Kenya. A greater understanding of what is preventing access to finance for such technology and the appropriate actions to improve and sustain access was needed to help achieve KIWASH output 2: Sustained access to finance/credit for WASH increased. Furthermore, should the technology be used by a greater number of people, the sustainable nature of solar powered water pumping compared to diesel or mains electricity alternatives has the potential to support progress towards KIWASH output 5: Environmental sustainability of WASH services increased. Appraising the barriers preventing rural community access of solar powered pumps and possible areas of action that the KIWASH project could use to mitigate such barriers formed the basis of this study.

2. Research Activities

Over a 3 week period (20th June -8th July), discussions and visits with stake-holders and users in the solar powered water supply sector (listed below) were conducted in order to gather the experiences of those with first-hand understanding of the difficulties and successes in accessing, and sustaining, solar powered borehole pumps. Furthermore, possible solutions and actions that would make accessing the necessary finance for such projects easier for rural communities were discussed. Meetings with organisations involved in the provision of solar powered water pumps included representatives from consultancies, finance institutions and suppliers. These meetings were recorded using a Dictaphone so that discussions could be revisited during the compiling of the report in order to avoid missing any valuable information. Visits to community borehole projects involved the completion of a standardized in-depth questionnaire (Appendices A-F) which provided continuity between data collected at different locations.

Organisation	Description
EED Advisory	Energy, environment and development consultancy with 2 years' industry experience including small rural schemes and large scale solutions in Somalia
African Solar Designs	Renewable energy design and consultancy with 25 years' experience with donors such as DFID, USAID, GIZ and also the World Bank and UN
Davis & Shirtliff	Leading supplier of water related equipment in East Africa
Winrock International	International Development Company – Implementing USAID

	Kenya Smallholder Solar Irrigation Project
Sidian Bank	Bank with experience of loans for renewable energy projects including for solar lighting and Water Service Providers, partnering with USAID and Water Services Trust Fund of Kenya
Grundfos	Multinational water pumping solutions provider

Community Projects	**Description**
Upper Kihara Water Supply Project	Project serving around 4,000 people
Uhuyi-Ruwe Water Supply Project	Project serving around 2,000 people
Ugoso-Sirandumb Water Supply Project	Project serving around 500 people
Kojunga Water and Sanitation Project	Project serving around 2,000 people
Kakuli Water Project	Project serving around 3,000 people
Kwa Nzili Water Project	Project serving around 7,000 people

The questions posed to organisations were tailored to gain the most valuable information possible from their specific experiences and areas of expertise. These discussions were not fully rigid, but rather the pre-determined questions were used to shape the course of discussions whilst unexpected but valuable information could be explored further. Additionally, after each meeting the questions were often slightly adapted to reflect the discoveries and areas of interest that were developing and evolving during the study.

The counties visited were revised from the four stated in the SOW (Annex B); Busia, Siaya and Kisumu in the west and Kitui in the east to; Siaya and Kisumu in the west, Makueni in the east and Kiambu in central Kenya. It was agreed with KIWASH that this range of counties would provide sufficient climatic and cultural variations to give a suitable representation of projects present in the nine target counties.

The questionnaire used was modified after the first visit to a community project (Upper Kihara Water Supply Project) as using it in the field flagged up some areas of inquiry that were lacking or needed improvement on the questionnaire itself. The questionnaire contained a mixture of quantitative questions (number of users, cost of installation, annual revenue, etc.) and more lengthy qualitative questions focusing on personal experiences. The combination of qualitative and quantitative data enabled the comparison of key numerical characteristics between projects whilst simultaneously providing experiences and opinions of community borehole users and managers. This

provided explanations about what factors were enabling or preventing the success of projects and what could be changed to ensure greater access and success in the future.

3. Research Findings & Evaluation

The findings of this study can be broadly divided into two elements: barriers to the initial access of community solar borehole pump projects and barriers which are preventing the long term sustainability of such projects. Whilst these two elements are strongly interlinked, it will become clear that in order to understand and remove barriers preventing new projects from being developed, issues hindering the sustainability of current projects must first be understood and acted upon.

Management

The first issue that was identified in several projects that were visited was a lack of proficient management by PMCs. A common problem seen across most projects was that donor assistance was predominantly focused on the short term. After assisting with installation, basic management training may be given which, although helpful, is not continued over the required timescale of several years in order to help maintain effective management. Project management often changes hands when members become dissatisfied with management issues, but new PMCs do not receive any follow up visits from donors to provide training in order to help them operate effectively. Appendix A shows that Uhuyi-Ruwe's PMC was unelected and untrained. Their first year finances showed a loss of 35,000 KES. Ugoso-Sirandumb (Appendix B) had a similar issue; the PMC was trying to do its best but their lack of training on how to run a commercialised operation was evident in their annual salary for the watchman alone (24,000 KES) exceeding the project's annual revenue of around 22,800 KES. This PMC had not enforced payment from the start of the project and had only managed to do so after agreeing to an incredibly low flat-rate of 50 KES per month for each household. The common tariff for water in rural community projects is 2 KES per 20L, meaning that 50 KES should buy 500L. The average sized household of around 5 people will use considerably more than 500L per month. This means that the project is missing out on a large amount of potential revenue should water be charged per unit. The Kojunga project (Appendix C) had a similar issue of not initially charging for water. After 3 years, a new committee was put in place. The new committee is attempting to collect payment for water but their lack of management was still evident. They could not explain where their revenue had gone (suspicions of self-payment from profits), did not know how to read meters and were struggling to address the issues of broken kiosks and a slowing pump. Common to these issues across all three projects was a lack of training and know-how from the PMCs in how to run operations transparently, efficiently and sustainably.

In contrast, there were some projects which were showing signs of more successful management. Upper Kihara (Appendix D), Kwa Nzili (Appendix E) and Kakuli (Appendix F) had PMCs which included educated and informed members. Ex teachers, railway manager and other trained professionals were clearly correlated to the more effective running of projects. For example, the Kwa Nzili project had been able to pay for repairs independently and the Kakuli project was managing to collect monthly revenue of 40-50,000 KES through a mixture of kiosks and private connections. The Upper-Kihara project, consisting of three solar powered boreholes, had used its solar technology for 10 years and it was still largely successful, despite one of the pumps being broken during the visit. The project's technician retrieved the submersible pump from the well without external help and took it

for diagnostics. The scheme's committee showed that with experience and know-how, a project can be run for many years, although improvements need to be made for their finances to become adequate to pay for full replacement of solar technology in the future. By contrast, the Kojunga project was only 4 years old yet was already reduced to 1 out of 4 kiosks being operational, an issue that the inexperienced committee was not able to address. Discussions with Grundfos, African Solar Designs and Sidian Bank all emphasized that in order to access finance, banks must have trust in project's ability to repay loans; without proper management, projects cannot operate in the organised manner that is required to be financially and operationally sustainable and hence generate the trust of lenders.

Revenue Collection

For any water project to be sustainable, it must ensure that its income from water payment exceeds its costs for wages and maintenance to such a degree that profits can be accumulated to create a fund for expensive repairs and replacement of parts after they have exceeded their design life. African Solar Designs raised the issue of payment for water, stating that it should be a resource people pay for, even if the amount is fairly low. They suggested that this would help to cover O&M costs and sustain the running of any given project. Sidian Bank also indicated that a project should be run as a business to be sustainable and to qualify for a loan. This bank offers interest rates of 17-19% for loans up to $100,000 USD, compared to a more common rate of around 24% in Kenya. There are several aspects of revenue collection which need to be addressed.

Visiting projects revealed that a common problem experienced by PMCs was that many users were not willing to pay for water. In the cases of Kojunga and Ugoso-Sirandumb, this was made worse by initially not charging for water when the projects first commenced, making users reluctant to change to a payment approach. Even where payment had always been required, a lack of understanding about the benefits of safe water from boreholes was clear. Many potential users were simply not educated about the importance of safe water and hence opposed to the relatively small charge for water which would enable huge improvements to health, security and livelihoods. The Kakuli PMC described some community members as 'ignorant', illustrating how they continue to search for scarce rainwater deposits in riverbeds and shallow wells in the semi-arid Makueni County. The Ugoso-Sirandumb project had noticed based on personal observations, a sharp decline in diseases such as typhoid (from drinking contaminated water) and malaria (from exposure to mosquitos at alternative water sources) in those who used the borehole supply. They admitted that those who refused to pay to use the safe water were not aware of the benefits identified by the WHO[2], including a sharp decline in cases of diarrhoea and a proportionate reduction of related deaths as well as cost savings in healthcare from reduced expenditure on treatments and avoiding lost working hours. The PMC believed that the money they would save on medicine would probably offset the expenditure on water education of potential users is necessary to increase custom and therefore revenue. At a more basic level, it is also needed to improve the health and livelihoods of many rural dwellers.

A factor hindering the sustainability of several projects was the lack of appropriate tariffs. Clearly, it is important not to exploit community users through the overcharging of water, however they must

[2] World Health Organisation. (2004). Evaluation of the Costs and Benefits of Water and Sanitation Improvements at the Global Level. World Health Organisation: Geneva.

pay a fair price in order to ensure that the operation of any given water project can remain commercially viable and therefore sustainable. The standard price charged by most projects for a 20L jerry can at kiosks was 2 or 3 KES which translates to 100-150 KES / m^3. This price is regulated by the Water Services Regulatory Board[3]to ensure that water remains affordable. In the case of the Kojunga project, private connections at a flat rate of 300 KES / month were open to exploitation and were limiting the revenue collected by the project. The Ugoso-Sirandumb project showed a more extreme case of undercharging, with a 50 KES / month tariff for each household for unlimited use from kiosks. There is some discrepancy between the estimated water consumption needs of rural communities. The lower estimate is provided by the Kenyan Ministry of Water and Irrigation whose Practise Manual for Water Supply Services states 10L per person per day as the minimum requirement for low potential rural areas[4], rising to 15L and 20L for areas of medium potential and high potential respectively. However, the WHO states that each person requires a minimum of 20L each per day[5] for basic survival, a household of average size (5 people) would therefore spend a minimum of 300 KES per month at a rate of 2 KES / 20L. However, the same WHO paper states that up to 70L is required per person per day for sustained living, and even more for a long term solution. Even the lowest usage estimate of 10L per day would still equate to 150 KES per month, three times the amount charged by the Ugoso-Sirandumb project. Projects like Ugoso-Sirandumb need to mix awareness and financial management to ensure that water is charged for fairly and sustainably.

Flat-rate tariffs were seen in several cases, including for private connections in Kojunga. Where rates are not charged by 20L unit at kiosks, it is important that payment is still correlated with water use. The use of water meters is vital. Kojunga had meters installed for private connections but the PMC was not aware of how to read them. In such instances, training is required to make revenue collection fair and to reduce exploitation of unlimited usage tariffs. Where meters have not been installed, this deficiency must also be addressed. The Uhuyi-Ruwe project, for example, had neither the knowledge of how to read meters nor an adequate number of meters to measure non-revenue water losses. It is essential that projects are equipped with not only a master meter but also functional calibrated meters at kiosks so that they are able to measure how much water has passed through outlet taps. This enables PMCs to track revenue collection and find out whether collectors have declared all of the money they have collected, increasing accountability and reducing loss of income. Meter reading is necessary to track water use, non-revenue water losses, water storage and water pumping. To successfully manage a water supply project, the PMC must have an up to date understanding of the state of the project and its water supply. To achieve this, meter installation and education is needed.

Accountability of water kiosk collectors was identified by all projects using kiosks as an issue that needs to be addressed. For example, the Uhuyi-Ruwe project identified the fact that, combined with a lack of water metering, they could not ascertain how much water had been sold and hence how much the kiosk collectors should be depositing to the project. They had suspicions that the collectors kept some money hidden from the PMC in order to increase their income which was based on 40% of the money they collected. Although a percentage payment provided more security to the PMC

[3] Water Services Regulatory Board. (2015). Impact Report: A performance Review of Kenya's Water Services Sector 2013-2014. Issue 8.
[4] Republic of Kenya Ministry of Water and Irrigation. (2005) Practise Manual For Water Supply Services.
[5] World Health Organisation. (2013). How much water is needed in emergencies. World Health Organisation: Geneva.

during rainy periods where project water usage declined, it also increased the likelihood of collectors syphoning money off for themselves, especially when their income fell. In Makueni County, the Kakuli and Kwa Nzili projects were in the middle of installing new AQtap water dispensers from Grundfos during the visits. These systems make use of smartcards that can be loaded with money using commonly used mobile payment methods such as M-PESA. Users can only use water from the tap when they have a balance on their card and no money is handled during transactions. Grundfos described this technology as extremely promising, showing examples of increased revenue collection and reduced non-revenue water losses. They predicted that the payback time for the approximately $5,000 technology would be 3-4 years but one of the first trialled units had a pay back of just one year. This technology is still during the earliest stages of roll-out but the current examples indicate that there is great potential for retrospective roll-out across solar water projects in order to increase financial accountability, revenue and sustainability. In Makueni, the PMCs of both projects visited were predicting that their revenue would increase and that managing their finances would be simpler due to the collected money being automatically deposited into a bank account. As more units are installed and used in the field, the potential of this new technology should continue to become clearer.

Maintenance

One factor that was clear in most projects was a lack of education and ability to perform basic maintenance. Some projects such as Upper-Kihara and Kakuli had the ability to perform basic repairs such as fixing pipe leakages themselves but many projects did not. When discussing the slowing pump rate with the Kojunga PMC, they were unaware that solar panels must be cleaned periodically, a simple procedure that may have helped to raise the declining pump rate somewhat. It is this basic level of maintenance that projects should be able to perform themselves, both to save expenditure on plumbers and technicians and also to keep projects running efficiently with adequate water supply in order to maintain revenue. It is not expected of PMCs to be able to fix technical problems without assistance, but a greater level of understanding of basic O&M is important. Alternatively, suppliers such as Davis and Shirtliff do offer service contracts whereby PMCs pay an agreed fixed price which entitles them to receive maintenance from an approved technician for no additional cost. However, such contracts exclude the replacement of expensive components which is the biggest financial challenge in terms of keeping projects running over the long term. Service contracts make it simpler for PMCs to arrange maintenance although field visits suggested that finding a suitable technician was not commonly an issue. Raising the required funds was the main obstacle and one that must be met to pay for service contracts too. As such, whilst more investigation into the potential of these service contracts would be useful, they are much less of a priority than ensuring that projects can fund O&M in whichever form they decide to use, whether that be independently or via subscription to service contracts.

Furthermore, the potential involvement of County Governments in supervising the management of projects is currently hindered by a lack of data and therefore awareness of community projects. The Kojunga project initially filled its 50 m^3 tank in 9 hours, but this had slowed to nearly 2 days. No evidence of this was possessed by the government or the PMC, other than by word of mouth within the PMC. WSBs, which formerly implemented rural projects, need to be involved in handing over all information concerning community water projects to the relevant County Governments so that the

respective County Governments are able to fulfil their responsibility of assisting their rural constituents.

Future Finance

By addressing these issues surrounding current projects, financially sustainable practices will be formed. Creating more independent and well run projects that generate revenue capable of financing repairs and maintenance is necessary to persuade the financial sector that lending for the creation of similar projects elsewhere is an attractive proposition which is not a risk but rather a sound investment. Sidian Bank was clear in stating that their business is about making money, if they see that there is the ability to repay a loan, they will be interested in lending. In order to become aware of this repayment ability, Sidian Bank stated that business models and plans are needed to highlight how exactly repayments will be met. Whilst no details about precisely what details such business plans should contain, Sidian Bank was clear in stating that proof of self-sufficiency and ability to generate sufficient revenue to repay loans was necessary. Further details could be gathered through discussion with Sidian Bank. Building trust within Sidian Bank and other lending institutions that such kinds of projects have the capacity to repay loans can be supported by using existing projects currently showing the financial capacity to repay loans as educational case study sites.

During a meeting with Davis & Shirtliff, East Africa's leading supplier of solar and pumping technologies, it was stated that financing is the biggest issue preventing a greater uptake of community solar pumps. Appendix E shows that the initial cost of a scheme can be as high as 11m Kenyan Shillings (KES) ($110,000 USD) for a community of 7000 people. For rural communities of low income, this presents an unreachable financial target if they wish to finance a project independently. All of the projects visited had received donor funding in order to overcome this significant financial obstacle. These findings endorsed discussions with EED Advisory who identified funding through third parties as vital. Whilst donor assistance has been an important facilitator for the formation of projects, in recent years funding has been declining. In order to ensure that communities can still access solar powered water pumps in the future, there must be increasing involvement of financial institutions providing loans. This approach has the potential to not only prevent a decline in the uptake of schemes but even to open up access to a greater number of communities.

Before new projects can be funded, it must be shown through the improvement of existing projects that community water projects can become financially sustainable and commercially managed. A meeting with African Solar Designs, a renewable energy consultancy, exposed the fact that a lack of trust and understanding in solar pumping from banks makes them hesitant to lend for such projects.

This issue has previously been seen in the micro-finance industry in relation to personal solar pumps for small-holder farmers involved in the Kenya Smallholder Solar Irrigation (KSSI) project. Winrock, the manager of the KSSI project identified the importance of educating loan officers and building up trust through the demonstration of successful examples. Winrock provided a $500 (USD) 25% subsidy for the purchase of a small Sunculture solar irrigation system to the first 5 'early adopters' in each target county. These early schemes showed great benefits and through the education of MFI loan officers using these successful examples, MFIs are becoming increasingly willing to lend to farmers who intend to buy similar products. This technology, encompassing solar arrays and water pumps, is the most closely related technology to community borehole pumps that has shown

evidence of building trust through its success in order to increase access to finance. The close link between the two indicates that there is potential for a similar approach for solar borehole pumps. The MFIs have shown the willingness to be flexible in repayment plans to cater for seasonal incomes thanks to their improved understanding of their customers' livelihoods and their ability to repay loans. Whilst the $1,000 USD loans from MFIs are insufficient to fund a large scale community supply project, Winrock suggested that if a similar approach of educating loan officers through the demonstration of successful projects could be translated to community projects then there may be potential for increased lending from MFIs or larger financial institutions. African Solar Designs discussed the need for banks to trust the ability of communities to repay loans in order for them to lower their interest rates of around 24% which would encourage communities to apply for loans. Trust is also needed for banks to approve applications when they do start to be submitted. Discussions with Grundfos further endorsed the fact that using successful examples to cultivate the trust required by financial institutions to provide credit is an exciting area of action with the potential to increase access exponentially.

Sidian Bank also has experience of partnering with donors in order to make financing more achievable and less risky. Whilst Winrock provided a 25% subsidy, Sidian Bank has an agreement with the Water Services Trust Fund of Kenya. Within this fund, the World Bank offers output based aid subsidies for commercial loans to WSPs. This fund assesses applications and upon approval, provides a 60% subsidy for loans which is paid in instalments upon confirmation of stages of installation being met in order to ensure the subsidy is used properly. On top of this 60% subsidy, half of the remaining 40% is guaranteed by USAID's DCA in case the loan taker defaults. Sidian bank charges a 17-19% interest rate which is significantly better than most Kenyan banks which charge around 24%. Sidian Bank stated that reducing their risk to 20% of the cost of projects is essential in order for them to be satisfied that they are not taking undue risks. This shows that currently, it is overly optimistic to assume that projects can be financed 100% by a loan. It is necessary to work in stages towards financial independence from donors. The example of Winrock's subsidies and Sidian Bank's partnerships shows that progress towards joint financing combining donors and loans is being made. Sidian Bank expressed their belief that communities applying for finance for solar boreholes have the ability to be approved by the Water Services Trust Fund subsidy although this needs greater investigation. Furthermore, they indicated willingness to explore the potential partnership that KIWASH could form with Sidian Bank, whether that is acting as a subsidy provider, guarantor or an awareness and capacity builder, assisting with applications and business like management of projects.

Awareness of the availability and potential of solar borehole pumping

As well as identifying new possibilities for financing projects with less reliance on donors, an issue that was raised by Grundfos, Winrock and African Solar Designs was a lack of awareness of all key stake holders in relation to the potential that solar borehole pumps have to be financially sustainable and beneficial. As already discussed, finance institutions need to be made more aware of the capacity of future projects to meet repayments and hence be an attractive area for lending. African Solar Designs and Winrock identified the awareness of community groups as an issue preventing access to solar pumps. This issue was seen in the field, where most projects, including Kwa Nzili, Kojunga and Uhuyi-Ruwe had only considered solar borehole pumping after the idea was suggested by a third party charity, World Vision. There are surely many communities who would

benefit from similar water supply projects that are not aware that the technology exists or that they have the potential to access it. Identifying these communities and helping to raise awareness, alongside assisting with applications, is an area that could increase access for many communities.

Davis and Shirtliff raised the issue of a lack of Water Service Provider (WSP) awareness, endorsed by the fact that existing lending agreements between Sidian Bank and WSPs outside of Nairobi, for developing sustainable water and sanitation services rarely, if ever, include solar pumping. Alongside raising community and financial institution awareness, raising WSP awareness has the potential to see larger scale solar borehole pumps being installed, helping to improve water provision for a large number of people. Sidian Bank explained that WSPs are starting to venture out of urban areas, and although remote communities are unlikely to be supplied by WSPs in the near future, rural towns and peri-urban areas could benefit from sustainable water supply if WSPs become more aware and willing to adopt solar pumping technology.

Furthermore, African Solar Developments expressed concern that current county government ministries are organised in ways which overlook the importance of energy, often grouping the role of addressing energy issues with other responsibilities which can prevent sole focus on tackling energy issues effectively. The county government website for Kisumu states that energy is part of the ministry of 'Industrialisation, Energy and Enterprise Development' whilst for Kitui there is a ministry for 'Environment, Energy and Minerals Investments Development'. The fact that these ministries are focused on developing 'industrialisation' and 'minerals investments' suggests that small scale renewable energy development is not a priority for these county government ministries.

4. <u>Recommendations</u>

Issues: Sustaining existing projects

1. Poor management of projects:
    - KIWASH can educate PMCs in several areas through workshops, visits and paying for courses:
        - How to manage and record finances appropriately.
        - How often to consult the community to discuss issues and concerns and how disputes should be resolved.
        - How to be transparent through the recording of revenue collection and water use (meter reading).
    - KIWASH capacity builder to attend PMC meetings at regular intervals in order to provide advice and assist the PMC with new and ongoing issues.
    - Provide or arrange training for basic maintenance of solar arrays, pipes, meters and pumps.
2. Revenue collection issues:
    - Improve tracking of water usage by providing funding for the installation of water meters and training on how to read them.
    - Encourage projects to move away from cash payment and adopt mobile payments (viable at kiosks and private connections) or direct payment to a project bank account (most viable for private metered connections).
    - Continue to monitor the success of Grundfos AQtaps over the next few months as a potential solution to cashless water payment. If successful, explore partnership with

Grundfos and their distributors, to retrospectively equip projects with this improved revenue collection system. Consider subsidising or lending for these systems, especially if pay back times continue to be so low.

3. Willingness of users to pay:
    - Ensure that new projects introduce payment for water from the start.
    - For existing and new projects, consult communities and provide, or help PMCs to provide, education that highlights the health benefits of drinking safe water compared to alternative sources and the consequential benefits of time-saving, ability of children to attend school, cost-saving from medication for illness from contaminated water, etc.
4. Basic maintenance education:
    - Provide O&M training and education where necessary for existing and future projects in order to keep projects running at a high capacity for as long as possible without unnecessary expenditure on technician call outs.
    - Require suppliers to include this basic training during the installation phase as standard. Although suppliers suggest that they already do this, experiences in the field suggest otherwise.

Issues: Accessing solar pumping equipment for new projects

5. Use established, successful projects (once current issues have been addressed) to raise awareness and promote lending:
    - Once existing projects are showing the capacity to be self-sufficient and commercialised, they can be used as case-study examples to educate potential lenders of finance.
    - Run workshops and seminars with appropriate organisations to improve their willingness to lend.
    - Consider establishing 'demo-pilots' financed by soft-loans and funding similar to Winrock's KSSI projects which can be used as case-studies to promote awareness with financial institutions.
6. Identify communities that have the capacity to operate successful solar borehole projects:
    - Gather information about number of potential users, need for upgrading water supply, willingness and ability to pay for water, etc. Evaluate all factors in order to prioritise communities most suited and in need of solar borehole pumps.
    - Raise awareness in potential communities about the benefits of solar projects to improve reputation, awareness and interest in order to increase uptake of solar boreholes.
    - Communicate between communities interested in applying for project finance and potential lenders and suppliers.
    - Help to produce thorough applications with the aid of county governments, include training of new PMCs, inclusion of AQtap/cashless payment if possible, forecast revenue and expenditure, contingency plans for repairs, how repayments will be met, etc.
7. Explore the potential for partnership with Sidian Bank, and other financial institutions if appropriate:

- Discuss the suitability of Sidian Bank's current arrangement with the Water Services Trust Fund of Kenya and USAID's DCA for subsidising community solar borehole project applications. Currently this subsidy is for more urban-focused WSPs but Sidian Bank expressed belief that there was some potential for this to be translated or replicated for rural projects.
- Investigate the potential of KIWASH to act as a subsidiser or guarantor for loans for community solar borehole projects provided by Sidian Bank and/or others.
- Consider how KIWASH can also act as an intermediary between communities and financial institutions, assisting with preparation and submission of applications and capacity building of community projects.

8. Partner with county governments to encourage WSPs to use the technology at a larger scale:
    - Discuss with WSP representatives, finance institutions, providers and county governments to promote the uptake of solar pumping at a larger scale in rural towns and peri-urban areas.
    - Raise awareness of the long term cost benefits for WSPs and encourage financial organisations to provide finance for WSPs which are naturally more commercially focused.
9. Create a management package that can be used to educate, organise and empower new PMCs to run successful projects:
    - Include training for each committee position, with a focus on core management skills and role specific responsibilities.
    - Form a training scheme that highlights basic commercial management practices and water specific skills such as meter reading, non-revenue water tracking and revenue collection.
    - Improve the accountability of PMCs through the use of cashless payments and formal agreements with project bank accounts that transactions must be agreed to by several members of the committee to minimise corruption.
    - A standardised, but adaptable, management approach that is instilled in PMCs from the outset will be an effective way of encouraging good practice and management of projects. The importance of good management has been highlighted and by helping to achieve this, future projects will be able to access loans more easily and operate in a more sustainable manner.

10. Enabling policy and legal environment:
    - Although the Kenyan government has been exempting imported solar equipment from excise duty (25%) & VAT (16%), the same exemptions have not been extended to locally assembled solar products. If such exemptions were applied, unit costs of the equipment could be reduced leading to greater use and creating local employment.
    - Both the central Government and County governments have been subsidizing the cost of power for many water companies and rural water supply schemes but do not have a subsidy or grant policy for water supply schemes that would use solar power.
    - Whereas the Government has gazetted several energy development initiatives, it is yet to set aside a special purpose investment vehicle for the funding of small scale solar energy generating companies such as the Power Africa Off-Grid Energy Challenge, an initiative of the US Government.

Solar array and water kiosk at Kojunga Water & Sanitation Project, Nyakach, Kisumu.

5. Annexes and Appendices

- Annex A: Inception Report and Work Plan for KIWASH Community Solar Borehole Research
- Annex B: Scope of Work
- Appendix A: Uhuyi-Ruwe Project Survey
- Appendix B: Ugoso-Sirandumb Project Survey
- Appendix C: Kojunga Project Survey
- Appendix D: Upper Kihara Project Survey
- Appendix E: Kwa Nzili Project Survey
- Appendix F: Kakuli Project Survey

Annex A

Frank Meakin - Inception Report and Work Plan for KIWASH Community Solar Borehole Research.

Inception Report

Objectives and Duties

- *Develop an inception report and work plan prior to arrival in country. Inception report should describe potential for solar powered community boreholes. The work plan will provide a timeline of activities to be undertaken along with locations, survey tools and approach description.* Addressed in this document.
- *Conduct field research in four counties in order to provide recommendations to KIWASH staff concerning Outputs two and five: Output 2 – Sustained Access to Financing/Credit for WASH increased and Output 5 – Environmental Sustainability of WASH services increased.* Plans for field research included in the work plan below. The recommendations produced as a result of research will directly assist in achieving Output 2. This will lead to increased uptake of solar borehole pumps which will in turn help to achieve Output 5 due to the sustainable nature of solar pumps (see work plan below).
- *County Research Progress Report will be a 2-3 page report detailing the progress made in survey at the midpoint of the assignment.* This report will be produced after visiting three counties in the west of Kenya (Kisumu, Busia and Siaya). At the midpoint, community projects, solar providers and other stakeholders will have been interviewed. This will allow progress to be evaluated fully and enable further areas of research to be identified which can be accomplished in the following two weeks.
- *Draft report to be submitted for comments to KIWASH staff by August 1, 2016.* Writing of the draft report will begin in the final week in Kenya (11th July) if adequate interviews have been undertaken. If not, this will commence and be finished upon returning to the UK.
- *Final Report delivered to KIWASH staff to include findings and recommendations.* Feedback from the draft report will be used to make necessary amendments in order to produce a suitable final report. The table of contents of the final report will consist of the following outline:
    1. *Executive Summary*
    2. *Introduction*
    3. *Research Activities*
    4. *Research Findings/Evaluation*

5. *Recommendations/Conclusion*

Potential for solar powered community boreholes

Falling prices of solar powered technology over the last decade has made photovoltaic water pumping (PVP) for boreholes in rural communities a feasible alternative to traditional diesel water pumping (DP) or electricity mains power. Research into the cost effectiveness of solar powered pumps shows that lifecycle costs of PVP can be between 20%-55% of the cost of the equivalent DP, despite higher initial costs of solar powered equipment (EMCON, 2006). The substantially lower operating price of PVP, due mainly to savings in diesel, means that break-even times for PVP can be as low as 2 years (Figure 1) and that savings from diesel can be enough to repay loans used for installing PVP (Desert Research Foundation of Namibia (DRFN), 2008). Whilst storage of water in elevated tanks can reduce peak flow strains on pumps, traditional rural societies often still collect water twice a day meaning that PVP must be able to cope with high flow rates to maintain this traditional lifestyle. The ability of PVP to match this need can be seen in a solar pump installed in Shalpin, Northern Pakistan, which is able to provide for around 1,000 people whilst yielding annual cost savings of over approximately $1,500 (Lorentz, 2012). The potential in Sub Saharan Africa is evident in a recent feasibility study of Siadeberand Wayu, Amhara region, Ethiopia which has calculated that a single solar pump could provide for around 700 people whilst yielding a 50% reduction in the cost of water over a 20 year life span (Girma et al., 2015). Furthermore, a recent interview by the World Bank Group (2015) reveals that developments to PVP in the last decade have made "it possible to pump 20 cubic meters per hour from a depth of 220m, and at the same time save more than 40% on O&M costs." With Kenya having an ideal climate for solar technology, illustrated in Figure 1, PVP offers a feasible and sustainable water supply solution for rural communities in Kenya. Importantly, this could help to reduce poverty through savings in fuel and maintenance as well as having major health benefits due to improvements in hygiene and reductions in water borne diseases and diesel emissions.

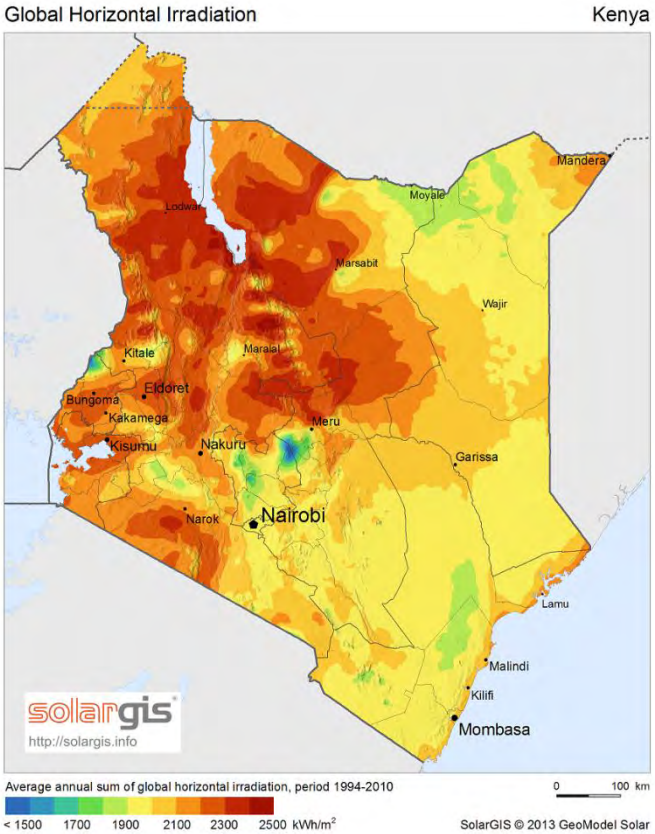

Figure 1: Global Horizontal Irradiation in Kenya. The majority of Kenya receives solar horizontal irradiation in excess of 1900 kWh/m² per year Source: SolarGIS.

Recent research by UNCDF and UNDP (2012) on clean energy in the world's poorest highlights how a "lack of appropriate end-user finance schemes has impeded reaching low-income market segments on a wide-scale" (page 2), and that appropriate financing arrangements are crucial to overcome this financial constraint, suggesting microfinance as a solution. Energy companies lack lending expertise but it is proposed that relationships between such companies and Microfinance Institutions (MFIs) could prove effective. Earlier work by Morris et

al. (2007) suggests that MFIs should partner with local energy companies to branch out to rural and poor communities; this reinforces the argument of UNCDF and UNDP (2012). It is argued that joint ventures are important in this respect because MFIs lack experience or understanding in the costs, benefits and uses of modern energies. This solution is not universally accepted, as shown by Rolffs et al. (2014) who promote Pay-as-you-go services as they provide wider access to finance and adapt to customer's expenditure. Furthermore they don't rely on coordination between finance and technology providers as this is part of a single model. This provision of a service instead of a technology proved to address users' needs better. However, problems still exist including the poorest still not being reached and barriers to accessing capital. Broadly speaking, current research is not clear on the best approach to make sustainable energy accessible to the poorest communities. In the more specific context of rural water groups in Kenya, there is a need to understand better how best PVP can be made accessible and whether one single solution suits different areas or if tailored approaches are needed.

The encounter between the potential shown by PVP and the limitations of current finance approaches will be the key focus of this investigation. Considering the experiences and opinions of stake holders who have experienced first-hand the issues in this area will provide authentic insights into possible actions and solutions to improve access of finance for PVP.

Work plan

Research will use a semi-structured interview approach in order to gather findings and experiences from different stake-holders. The questions asked in interviews will be tailored to the specific interviewee but some questions will be used in every interview to provide continuity and comparison between stake-holder's responses. Interviews will be recorded using a Dictaphone to provide a source of future reference and to enable interviews to be undertaken without the distraction of precise note taking. This interview approach will be combined with the use of questionnaires that will provide standardized answers, enabling comparison of the data acquired from informants. Questionnaires will be especially useful for comparing characteristics of rural schemes such as the number of people it supplies water to, the re-payment timescale and how it charges for water access. The approach to this assignment is to gather the experiences and suggestions from stake-holders in the community solar powered borehole sector in order to fully understand the complex issue of accessing finance/credit for solar powered borehole pumps. Through gaining a detailed understanding of this issue, it will be possible to make recommendations to KIWASH that can be implemented and lobbied for in order to increase access to finance/credit which will in turn increase uptake of solar powered borehole pumps. This will directly assist KIWASH Output 2 (Sustained Access to Financing/Credit for WASH increased). The sustainable nature of solar powered borehole pumps compared to commonly used diesel pumps means that increasing the use of solar pumps through Output 2 will in turn stimulate progress towards Output 5 (Environmental Sustainability of WASH services increased).

Week beginning 20th June	Nairobi	Attend interviews with ASD, Davis & Shirtliff and EED Advisory (plus any other meetings arranged prior to arrival in Kenya. Spend time at KIWASH offices making	Semi-structured interviews/ questionnaire. Use of Dictaphone to capture

		arrangements for following week in Kisumu area.	interviews for subsequent analysis.
Week beginning 27th June	Kisumu + day travel to Busia and Siaya counties. Arrangements TBC*	Visit and conduct interview at a solar borehole project in 3 counties: Kisumu, Busia and Siaya. Write up County Research Progress report on Friday 1st July.	Semi-structured interviews using Dictaphone/questionnaire.
Week beginning 4th July	Nairobi and Kitui*	Conduct further interviews in Nairobi area if possible. Day travel or one night stop for visit to Kitui county to visit solar borehole project (TBC)	Semi-structured interviews using Dictaphone/questionnaire.
Week beginning 11th July	Nairobi	Complete any necessary interviews around Nairobi. Begin to write up draft report. Trip to Kitui* could take place in this week instead.	Semi-structured interviews using Dictaphone/questionnaire.
Return to UK 15th July	UK	Finalise draft report and send off for feedback. Amend report in order to prepare final report by end of August.	

*Plans for visits to solar borehole sites will be made upon receiving county level contact details from KIWASH in order for arrangements to be made. Further meetings with other stake holders will also be arranged before departure/whilst in Kenya.

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Annex B

EXHIBIT A
SCOPE OF WORK
KENYA INTEGRATED WATER, SANITATION, AND HYGIENE PROJECT
Community Solar Borehole Researcher

PROPOSED PERSONNEL	Frank Meakin	
POSITION	Community Solar Borehole Researcher	
PERIOD OF PERFORMANCE *ON/ABOUT (FROM – TO)*	May 5, 2016	August 31, 2016
BASE OF OPERATIONS	Nairobi	
POSITION REPORTS TO	Chief of Party	

1. PROJECT BACKGROUND:

The Kenya Integrated Water, Sanitation, and Hygiene (KIWASH) Project is a five-year, USAID-funded project to improve lives and health through the development and management of sustainable water, sanitation, and hygiene services in Kenya. Its purpose is to institutionalize catalytic models of sustainable service delivery for accelerated water and sanitation access in specific target counties and to improve complementary hygiene and health behaviors.

2. ROLE'S PURPOSE:

The consultant will be responsible for conducting studies across four project counties: Kisumu, Busia, Siaya, and Kitui. The study will assess the financial barriers to the uptake of solar powered borehole pumps within communities in rural Kenya. The study will make recommendations to assist the KIWASH Project to achieve two outputs, namely: Output 2: Sustained Access to Financing/Credit for WASH increased and Output 5: Environmental Sustainability of WASH services increased. The study will assist KIWASH in its aim to improve access and uptake of improved water sources for one million Kenyans. The study will advance understanding on barriers to accessing solar powered borehole pumps in rural Kenya and subsequently produce a package of findings and action points that KIWASH can use in order to help achieve its goals of increasing the sustainability of WASH services. The research in Kenya will take about one month with provisional timing for June/July 2016. Analysis and write up will be done in August 2016 and consist of findings and recommendations to enable increased rural community access to photovoltaic water pumping that can be implemented by the KIWASH project.

3. OBJECTIVES AND DUTIES

The consultant will be responsible for the following:

- Develop an inception report and work plan prior to arrival in country. Inception report should describe potential for solar powered community boreholes. The workplan will provide a timeline of activities to be undertaken along with locations, survey tools, and approach description
- Conduct field research in four counties in order to provide recommendations to KIWASH staff concerning Outputs two and five: Output 2 – Sustained Access to Financing/Credit for WASH increased and Output 5 – Environmental Sustainability of WASH services increased

- County Research Progress Report will be a 2-3 page report detailing the progress made in survey at the midpoint of the assignment
- Draft report to be submitted for comments to KIWASH staff by August 1, 2016
- Final report delivered to KIWASH staff to include findings and recommendations
- Other duties as assigned

4. DELIVERABLES

Deliverable	Due date
Inception Report and Workplan	May 25, 2016
County Research Progress Report	July 1, 2016
Draft Report	August 1, 2016
Final Report	August 31, 2016

Appendix A

Borehole: Uhuyi-Ruwe, Ugunja, Siaya (Village, Sub-County, County)

Coordinates: 0.197104 N 34.432094 E

Organisation of group: (voluntary/employed, committee, experience, elections)	Executive Project Management Committee of 6 people Project management Committee of 16 people Not elected, not trained. Probably take some money from the project although was not confirmed.
Age of borehole **How was it financed?**	2015 – Western Kenya Community Driven Development and Flood Mitigation Project (WKCDDFIP) (Kenyan Government and The World Bank).
Previous energy supply type	Hand Pump
Cost of previous supply per month	N/A
Depth of borehole	51m
Age of solar pump	2015
How did you become aware of solar pumps as an alternative?	WKCDDFMP ran some micro-projects such as poultry keeping, banana plantations and goat herds. Were introduced to the possibility of a solar borehole through this initial contact.
Were any third parties involved in accessing the solar pump? If so, who?	WKCDDFMP (Kenyan Government and World Bank)
Funder of pump	Kenyan Government/World Bank
Cost of pump	Cost of borehole: 797,500. Cost of civil works: 5,444,626. Cost of equipment: 1,195,676. Total Cost: 7,437,802. (KES)
How does solar compare to previous source of power?	Much improved. More places to access water, quicker.

Pump Rate	$5m^3$/hour – 60% of peak which is $11m^3$/hour – rules of WRMA. Although they weren't sure they had the abstraction license. Quite disorganised. 4,000L tank at each of the 4 kiosks. 10,000L main tank. Total 26,000L storage. 6 hours to fill everything, 2-3 hours to fill main tank.1 Master meter at the source and one at each kiosk but readings aren't taken. Not sure how to take readings and also require in and out meters at kiosks for accountability.
Number of users	200 homes upper area and lower area. Total 400 homes. Total population of area is 4,000 so currently serving around 50% of population. Borehole is adjacent to premises of a primary and secondary school, with two more schools in the area. Looking to reach an agreement to have a dedicated kiosk by the adjacent schools and possibly the other 2. Room for expansion.
Uses	Drinking water, some livestock.
Operation and maintenance costs per year	In first year, 21,000 KES. Issues with tanks being pierced by supporting 'pins' when flat timber should have been used. No air valves installed along pipe may cause future issues.
How are these paid for?	From revenue
Cost of water / unit	2 KES / 20L container. 40% revenue is paid to kiosk collector.
Single tariff or graduated	Single
Annual revenue/Volume of water sold	Around 200 KES collected per day at each Kiosk. Pay pump operator 2,000 KES/ month Annual revenue year 1 – 58,000 KES before payments. But total expenditure was 93,000 KES including kiosk collector's 40% cuts, maintenance works etc. Unsustainable and poorly managed, treasurer was not trained. Need an accountant/ training for the treasurer to manage the books properly.
Payment method	Cash
Benefits/Negatives of this method	Providing jobs. Easy and clean access to water. Accountability of kiosk collectors – no meter readings mean that the committee cannot be sure that all collected money is delivered to the committee.
Do you have a plan in case the technology breaks and needs to be replaced?	Bank some money collected from Kiosks.

What are most successful aspects of this project?	Created job opportunities, serving a large number of people (roughly 2000) with potential for expansion.
What are the biggest challenges facing this project?	Job opportunities hindered by irregular income from commission – when it rains, they get significantly lower income. Lower output when raining – although people tend to use rain water collection. Demand is exceeding capacity of tanks but the pump could cope with additional users. Nearby villages feel marginalised as they are not receiving the same benefits. Operator can't check when tanks are full as he has not got transport to travel the 1.5-3kms to the kiosks. Need to purchase overflow sensors or communicate via mobile with the kiosks collectors. Accountability of kiosk collectors – no meter readings mean that the committee cannot be sure that all collected money is delivered to the committee.
Do you know of a borehole project that doesn't use solar power? If yes, how do you compare your experiences with them?	No
Notes	PMC wasn't fully involved in construction of the project. Then the engineer was acting as secretary/chairman. Corners were cut – no air valves or shelves in the kiosks so that they could also sell cheap goods at the same time (raising collector's incomes). Davis and Shirtliff didn't provide training on simple maintenance – were unaware that they may need to clean the solar array to maximise its efficiency. Davis and Shirtliff provided 1 year warranty, PMC have no plans in case of expensive malfunction after this period. No training / knowledge of how to read the meters. This skill is needed in order to trace non-revenue water and keep kiosk collectors accountable. Treasurer did not keep proper records as he did not know how to. Currently, the schools are not metered for their use.

Appendix B

Borehole: Ugoso-Sirandumb, Ugunja, Siaya (Village, Sub-County, County)

Coordinates: 0.167925 N 34.297535 E

Organisation of group: (voluntary/employed, committee, experience, elections)	11 committee members. Executive committee: chairman, treasurer and secretary Voluntary project. Committee members pay the same for water as other users. No training or experience.
Age of borehole **How was it financed?**	August 2015. Paid for by East African Breweries Ltd Foundation (EABL).
Previous energy supply type	Collected river water from Uyuwe-Uyuwe river 2km away. Also a spring 3.5km away.
Cost of previous supply per month	0
Depth of borehole	2500ft – possibly incorrect?
Age of solar pump	August 2015 / 1 year
How did you become aware of solar pumps as an alternative?	Pricey electric pumping made them seek an alternative. Saw successful examples in the local area.
Were any third parties involved in accessing the solar pump? If so, who?	They approached the local MP for assistance.
Funder of pump	EABL Foundation
Cost of pump	5.7m KES for entire system
How does solar compare to previous source of power?	Much more accessible as no longer have to make the long journey for water.
Pump Rate	Not known but tank has $24m^3$ capacity and takes 2.5 days to fill.
Number of users	Main kiosk serves 8 households. Other kiosks serve 12 + 16. Total of 36 homesteads. Plus local school of approx. 350 pupils + 15 teachers.

Uses	Drinking water / domestic uses.
Operation and maintenance costs per year	3,500 KES in first year
How are these paid for?	Used revenue that had been saved but had to subsidise with personal savings.
Cost of water / unit	Houses pay 50 KES / month. School pays 100 KES / month. Unlimited use.
Single tariff or graduated	Single
Annual revenue/Volume of water sold	Approximately 1900 KES/ month. 22,800 KES / year.
Payment method	Cash. Collection of water via kiosks that open 10-2 and 4-6. Run by volunteers, locked at other times.
Benefits/Negatives of this method	Water could be exploited as users have unlimited use for a very small fee. No meters to record usage.
Do you have a plan in case the technology breaks and needs to be replaced?	No plan. Pay a night guard 2,000 KES / month to prevent theft or damage. Previously had to pay for a plumber to come for which a fee was negotiated. Now a local person has paid for himself to be trained.
What are most successful aspects of this project?	Malaria incidence has fallen since users stopped collecting water from the river where there is an infestation of mosquitos. Potential for the project to expand to individual connections and bottle water which could then be sold. They have an accountant so their books are correct.
What are the biggest challenges facing this project?	Burst pipe, they think it is due to the pipe used being too thin/poor quality and also not buried deeply enough. Made financial losses first year, they described expenditure as 'loss' which shows capacity issues. Need to involve public health, water, and local administrations to persuade other villagers to use the water. Need educating on health benefits. 50 KES / month is way too low a fee for the water. Local consumers agreed and were willing to pay more but the PMC were unaware of this. Shows lack of communication and organisation.
Do you know of a borehole project that doesn't use solar power? If yes, how do you	No

compare your experiences with them?	
Notes	Committee meets 6 times per year and with consumers twice per year. Watchman's salary of 24,000 KES exceeds the annual revenue. No meter so they can't estimate usage. 16 homesteads have expressed an interest in paying for a metered personal connection. 600 locals are still not using the project's water in favour of collecting from the river. Room for expansion but need to attract and persuade the locals. The supply has never run out. Full tank lasts 1.5 weeks – shows capacity for expansion. Have not been using local political figures to promote the benefits of safe water and the savings in medical expenses that it can provide. The PMC has an 8 year plan to see individual connections installed. Average of 24,000 KES quotation for a personal connection 50-100m away from pipeline. There are '5m KES' homes nearby that use shallow wells. They should be approached about paying for a personal connection to the borehole water supply. Even the biggest homes pay 50 KES / month, not a sustainable amount. Quality of water falls when it rains, water goes a brown colour. Shows that the borehole was not constructed properly. Users don't seem to mind if the colour changes.

Appendix C

Borehole: Kojunga Water & Sanitation Project, Nyakach, Kisumu (Village, Sub-County, County)

Coordinates: 0.343048 S 34.920373 E

Organisation of group: (voluntary/employed, committee, experience, elections)	Small committee that includes a chairman, secretary, treasurer and 'engineer' (not qualified).
Age of borehole **How was it financed?**	2012
Previous energy supply type	Used to (and sometimes still do) use a solar powered shallow well provided by World Vision

Cost of previous supply per month	N/A
Depth of borehole	150m
Age of solar pump	2012
How did you become aware of solar pumps as an alternative?	Kojunga registered with the Ministry of Gender, Children and Social Development for help. The possibility of a solar borehole was raised.
Were any third parties involved in accessing the solar pump? If so, who?	Firstly the Ministry of Gender, Children and Social Development who in turn approached Lake Victoria South Water Services Board (LVSWSB) who in turn approached small consultants to submit applications. The best were shortlisted. The best application was awarded the contract to undertake the civil works whilst LVSWSB arranged for the installation of the pump and solar array.
Funder of pump	African Development Bank & Lake Victoria South Water Services Board.
Cost of pump	6.8m KES for entire works.
How does solar compare to previous source of power?	Initially it was very successful, kiosks reduced the distance people had to travel for water and the supply was reliable.
Pump Rate	Not known but the tank is $50m^3$. Initially it could fill in 6-9 hours but it currently takes 2 days, possibly due to the deterioration of the pump or solar array which have not been maintained.
Number of users	2000 users via 4 kiosks initially. Currently only 1 is operational. 51 households have private connections. 2 local schools also have connections.
Uses	Drinking
Operation and maintenance costs per year	Have paid 2,000 KES to unblock one section of the pipe.
How are these paid for?	Used money collected from users in the area affected. Users elsewhere were unwilling to contribute and so their connections are still broken.

Cost of water / unit	300 KES / month for private connections. 2.5 KES / 20L jerry can. The old are not charged for water.
Single tariff or graduated	Single. Meters have been installed on the personal connections but they do not know how to read them.
Annual revenue/Volume of water sold	At one stage were collecting 3,500 KES / month. Now collecting between 1,500-2,000 KES / month.
Payment method	Cash collected by a volunteer for personal connections / at kiosk by volunteer for others. If users default then their connection is cut off.
Benefits/Negatives of this method	Some customers have stopped paying. Even after 5 visits the volunteer has not collected the money. They give out receipts to track payments. Users are not buying into the fact that it is vital they contribute financially for their water use; they think they can get away with not paying.
Do you have a plan in case the technology breaks and needs to be replaced?	There has been no routine maintenance carried out due to a lack of knowledge, training and awareness. Although the committee said they have a bank account where the revenue is collected, they stated that when money was needed to repair blocked pipes, the users had to contribute their own savings.
What are most successful aspects of this project?	The first committee, who failed to collect money for the first 3 years, have been replaced by one which is attempting to. Water is more accessible to the community when the project is fully operational. Even in its current state, it is a more reliable source than the shallow well which is often dry.
What are the biggest challenges facing this project?	The community are not happy that they must now pay for water as initially it was free. They assume that because the project was provided free of charge to them that they shouldn't have to pay for the water it produces. Through either lack of maintenance or the degradation of the pump, the tank now takes over 2 days to fill compared to 9 hours at the start of the project.
Do you know of a borehole project that doesn't use solar power? If yes, how do you compare your experiences with them?	No

Notes	The supply of water has become irregular, often only working every other day. Pipes have been bursting increasingly frequently – contractor may have used sub-standard materials. These issues are being fixed by the committee and community themselves. The respondents noted that they had received no training or instructions on how they should maintain the solar array. The pump and solar array were installed by Davis and Shirtliff. The committee approached LVSWSB for additional money to carry out essential repairs but this was rejected. The need for follow up assistance from the county government was raised.

Appendix D

Borehole: Upper Kihara Water Supply Project, Mahindi Sub-Location, Kiambaa Sub-County, Kiambu County 24th June 2016

Coordinates: S 1.208724 E36.738844

Organisation of group: (voluntary/employed, committee, experience, elections)	Non-profit community project started in 1986 Voluntary management committee – 8 members. Elected around every 1 year. 3 employees.
Age of borehole **How was it financed?**	3 Boreholes drilled in 2006 (10 years old). Donor assistance from Lifewater International When the project was in its infancy, a loan from Kenya Commercial Bank was taken out to buy pumps for wells (150-80ft deep – may be incorrect depths?). High interest rates and member's property being used as collateral were negative factors. They found repayment difficult. Wouldn't consider doing the same again unless absolutely necessary.
Previous energy supply type	Electricity - AC
Cost of previous supply per month	Around 40,000 KES / Month
Depth of borehole	At the borehole visited, 150m
Age of solar pump	10 years (2006)

How did you become aware of solar pumps as an alternative?	Donor highlighted the possibility. Willing to listen due to high cost of electricity
Were any third parties involved in accessing the solar pump? If so, who?	Lifewater International – donor. Assistance was vital for the project to take place
Funder of pump	Lifewater International
Cost of pump	Roughly 6,000,000 KES
How does solar compare to previous source of power?	Overall solar is better. Although electricity produced a higher pump rate than now, solar is cheaper and more reliable
Pump Rate	They did not know
Number of users	800 families (Roughly 4,000 people)
Uses	Drinking, Livestock and Crops
Operation and maintenance costs per year	Around 35,000 KES
How are these paid for?	From money collected for water usage
Cost of water / unit	0 KES/m^3 up to 2m^3 60 KES/m^3 up to 5m^3 100 KES/m^3 up to 10m^3 200 KES/m^3 over 10m^3
Single tariff or graduated	Graduated
Annual revenue/Volume of water sold	30-40,000 KES / month. One chicken farmer paid around 4,000 KES / month, must be one of the main users.
Payment method	Bills are written to each user who then pays by depositing into the project's account at the bank
Benefits/Negatives of this method	This method of payment instils confidence that money will not be stolen or misused. Very successful way of collecting money

Do you have a plan in case the technology breaks and needs to be replaced?	Approach donors for assistance There are some savings to cope with repairs but not full replacement They have a meeting soon to discuss how they might collect a fund in the event of full replacement being necessary. Unwilling to consider loans due to past experiences and high interest rates.
What are most successful aspects of this project?	Much cheaper water than when using electricity before
What are the biggest challenges facing this project?	Currently broken for the past 4 days (24/06/2016). They think that the motor on the pump is broken. Repairs to pipes as the network is very large People not paying their bills – tackled by letters being sent. After 2 months the supply is ceased. Not willing to go to court due to community/family roots of project
Do you know of a borehole project that doesn't use solar power? If yes, how do you compare your experiences with them?	No, but noted that the high cost may discourage adoption of solar technology. Require education of the long term benefits in order to improve interest.
Notes	Figures may be inaccurate – the project's use of 3 separate borehole pumps made it difficult for answers to be given for individual boreholes.

Appendix E

Borehole: Kwa Nzili, Mbooni Sub County, Makeuni County (Village, Sub-County, County)

Coordinates: 1.723514 S 37.723239 E

Organisation of group: (voluntary/employed, committee, experience, elections)	9 volunteers on the committee, some of them had been teachers.
Age of borehole **How was it financed?**	1 year old (2015) Donor financed by World Vision
Previous energy supply type	Manual. Collected water from seasonal rains or from the surrounding river beds.
Cost of previous supply per month	N/A
Depth of borehole	120m

Age of solar pump	1 year (2015)
How did you become aware of solar pumps as an alternative?	Approached World Vision for assistance in improving water supply – World Vision suggested solar borehole pumping.
Were any third parties involved in accessing the solar pump? If so, who?	Yes – World Vision
Funder of pump	World Vision
Cost of pump	11m KES
How does solar compare to previous source of power?	Massively improved, no longer have to walk 3-4 hours for water. Accessible and time efficient.
Pump Rate	Didn't know.
Number of users	7000 people
Uses	Drinking and livestock. Evidence of half an acre of field drip irrigation.
Operation and maintenance costs per year	Replacing burst pipes – 6,000 KES in one year
How are these paid for?	From revenue collected from the sale of water
Cost of water / unit	3 KES / 20L container
Single tariff or graduated	Single.
Annual revenue/Volume of water sold	20,000 KES profit in 3 months

Payment method	Cash. 7 kiosks but only 3 functional. Pay kiosk operators 2,500 KES / month.
Benefits/Negatives of this method	After rain, notable decline in number of users as they chose to collect free rainwater instead. Not all money reaches the project bank account, suspect operators may keep some for themselves
Do you have a plan in case the technology breaks and needs to be replaced?	Pay with profit saved in bank account.
What are most successful aspects of this project?	Used to take 3-4 hours to collect water. Life has improved now they have access to clean water (health benefits). Users are happy to pay for water when there is no rainwater to collect. 150m^3 of storage lasts a few days if pumping slows due to clouds.
What are the biggest challenges facing this project?	There are many potential users who still refuse to pay for the clean water and instead are struggling to live on dirty and scarce rainwater. Loss of revenue through non-revenue water losses and accountability of kiosk collectors should be negated by the current installation of Grundfos Aqtaps.
Do you know of a borehole project that doesn't use solar power? If yes, how do you compare your experiences with them?	No
Notes	Considering a connection to nearest powerline (3km away) to provide back-up pumping for when clouds slow down the power generated by solar panels.

Appendix F

Borehole: Kakuli Water Project, Mbooni Sub County, Makeuni County (Village, Sub-County, County)

Coordinates: 1.717069 S 37.769178 E

Organisation of group: (voluntary/employed, committee, experience, elections)	9 committee members –volunteers. Commenced 2006 with every village local school, health centre and market represented by members at meetings. Teachers and other educated volunteers on the committee.

Age of borehole **How was it financed?**	April 2014
Previous energy supply type	Hand dug shallow wells.
Cost of previous supply per month	N/A
Depth of borehole	68m
Age of solar pump	2.5 years
How did you become aware of solar pumps as an alternative?	Approached World Vision for assistance after they compared the costs between electric, diesel and solar.
Were any third parties involved in accessing the solar pump? If so, who?	Yes – World Vision
Funder of pump	World Vision
Cost of pump	7m KES
How does solar compare to previous source of power?	Changed their lives. Before, water was a scarce resource that had to be searched long and hard for. Often had to drink dirty water and sometimes couldn't find any.
Pump Rate	Didn't know.
Number of users	Approximately 3000 people including 4
Uses	Drinking and livestock
Operation and maintenance costs per year	Didn't have records to hand.
How are these paid for?	From money collected for use of water

Cost of water / unit	3 KES / 20L container. Sub county water officer pointed out that WSRB has to approve tariff for water – Ministry produces an 'extraordinary tariff' for NGO projects of 2KES/20L. Slightly raised in this region to 3 KES / 20L by committee.
Single tariff or graduated	Single. 7 kiosks and private connections for schools. 6 attendants paid 4,500 KES / month. Pump attendant 8,000 KES / month. Clerk 6,800 KES / month. Watchman salary – not found but approx. similar to pump attendant and clerk.
Annual revenue/Volume of water sold	40-50,000 KES / month
Payment method	Cash.
Benefits/Negatives of this method	Missing water cannot be accounted for as they do not truly know how many sales there have been. Reliant on honesty of kiosk attendants. They were currently installing Grundfos AQtaps which they hoped would reduce non-revenue water and also increase the revenue collected due to the fact that this system does not use cash and therefore accountability of kiosk collectors is not an issue.
Do you have a plan in case the technology breaks and needs to be replaced?	Leakages, burst pipes have been paid for with money from the projects' sales. The pump operator carried out minor repairs but for big issues they called in a trained specialist.
What are most successful aspects of this project?	Increased availability of water. Children no longer have to travel up to 15km to collect water which improves security
What are the biggest challenges facing this project?	There are many potential users who still refuse to pay for the clean water and instead are struggling to live on dirty and scarce rainwater. An uphill sector of pipe where there was a gulley was repeatedly bursting. They planned to replace this with a metal pipe rather than plastic which was thought to have weakened prior to installation due to sun exposure.
Do you know of a borehole project that doesn't use solar power? If yes, how do you compare your experiences with them?	No

Notes	