Climate & Development Knowledge Network

Project Completion Report

Project Country/Region: Uganda

Project Title: Testing Synergies in Distributed Renewable Village Power in Africa

Date: 22nd December, 2015

Project Reference Number: AAGL-0047b

Note to supplier:

This progress report is intended to summarise the complete progress of the project. The report should be results focused – telling the story of the project, sharing lessons learned and emphasising how activities are working to meet objectives and have impact. Information should be presented in a short, succinct manner and it is not intended to be a lengthy document. Estimated size is over 12 pages long plus two 4-page appendices.

This progress report will normally be supplemented by a monthly catch up call with the CDKN project manager. The call will be used to discuss this report in more detail, where required.

This completion report may be circulated within the CDKN.

Please submit this report at the end of the project.

1. Project Details

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Project Reference Number	AAGL-0047b
Supplier Project Manager	Dr. Alastair K Livesey
Project Timetable	July 2014 to December 2015
Date of Report	22nd December, 2015

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2. Summary of Project

This project was funded by CDKN to provide a pilot test of Africa Power's **ABC+D** commercialisation model for Distributed (off-gird) Rural Village power, and as such was successfully completed in Uganda.

Africa Power's ABC+D Off-grid Rural Power Business Model

Africa Power's mission is to empower rural, 'off-grid' communities in sub-Saharan Africa by providing "Sustainable Electricity for All" using cell phone towers as anchor clients to provide power to unconnected households, micro-enterprises and community facilities thereby reducing poverty, increasing local economic activity and jobs, as well as improving health, education, communication & gender equality.

Africa Power is an independent power provider, which seeks to purchase, install, maintain and operate renewable and sustainable, low-carbon, off-grid power systems in rural areas in East & Southern Africa, where there is no access to grid electricity. Each system is priced to provide either:

- **An increase in profits** from a new or expanded business
- OR a **saving over the current costs** of provision of the services

without on-going Governmental subsidies or feed-in tariffs, etc.

Africa Power is an independent for-profit company, which believes that public/private partnership is necessary to bring "Sustainable Energy for All" to rural regions of emerging economies. We believe a fast growing, profitable business will provide the best guarantee of continuing maintenance and expansion of power provision in rural communities.

We divide our clients into 4 groups (the **ABC+D** model). Each distributed, independent Power System is tailored to the specific application.

- **Anchor** Clients: major creditworthy users of power such as the off-grid cell phone towers. This creates the maintenance network, to install and maintain the B&C customers and support our village agents.
- **Businesses**: Small micro-enterprises, where Africa Power supplies both the power and the equipment to build a business (e.g. drip-feed irrigation; agri-processing; refrigeration; power tools; etc), providing new jobs and an increase in the local economy.
- **Community facilities** such as Schools, Health Clinics, religious buildings, police posts, etc
- **Domestic Solar Home Systems** Pay-as-you-go systems bringing lighting, phone charging, radio, TV internet, & other benefits, over time and on an affordable plan, to those at the bottom of the pyramid. The Solar home systems include both the power and end-use elements in a single package.

Typical cell phone site on top of hill in Uganda. The tower we powered is to the right

In each village, we train one or more agents to stock and fit household solar power systems comprising three lights and a phone charger. These systems will work on a pay-as-you-go system, with the installer collecting a weekly fee, and the cell phone network used to unlock the systems. These systems cost half the weekly cost currently spent on candles and kerosene for light.

The Project

The project originally sought to trial the full A,B,C + D business model in a rural village in Uganda. Budget limitations and timetable constraints forced us to concentrate on the A, B + D aspects of the plan, because the provision of power in Community Facilities (Schools, health clinics etc) on a commercial basis usually requires the financial backing of the relevant Government ministry, which was unlikely to be obtained for a single pilot project.

Houses in the Buwofu Village where we installed the BCD village power systems

The goal was to install and test the following components in a village:

- **Anchor** client: A solar battery hybrid power systems for a cell phone tower.
- **Business:** A drip-feed irrigation project
- **Domestic Solar Home Systems (SHS):** to deploy SHS on a PAYG (Pay-as-you-go) plan to at least 50 households, with on-going sales as the value proposition for the villagers is proven.

As it transpired, however, circumstances contrived to allow us to add a **Community Facility** aspect to the project at no extra cost to the CDKN, although the late addition of this element forced us to redesign the drip irrigation water pumping project to accommodate both drip-feed irrigation (Business) and a supply of Clean Drinking water (Community Facility).

Thus in practise we completed the full A,B C + D model.

In line with CDKN's Knowledge Networking philosophy, **dissemination** of the knowledge gained was an important aspect of the project with 4 major presentations being targeted, plus a further 4 or so minor presentations. We classified Major dissemination activities to be either presentations to a large targeted audience (e.g. key-note speaker at a large conference targeting Africa; Development and/or Energy) or the presentation significantly advanced applying for or winning funding for further expansion.

CDKN were particularly keen to ensure the project was not seen as an isolated pilot project, but would lead to a **demonstration** and then **roll-out** of the successful aspects. A key expectation was that the learning would enable a viable development plan to be created leading to a stand-alone commercially viable business being formed. A significant fraction of the project was directed towards seeking funding opportunities to continue and expand the work in Uganda and to seek sufficient development funding to create a viable and sustainable business in Africa. The target was to submit at least 4 applications collectively seeking over $20m in funding. Decision making and contracting for development funds is a slow process, so it was not expected that major contracts (for between $5-10m) would be signed before end of 2016.

Summary Outcomes

- All tasks were successfully completed.
- All the engineered technical solutions were deployed and continue to function as designed.
- Africa Power is committed to monitoring; maintaining and supporting these projects for at least one year from deployment, without further funding, and to seek funding to enable a sustainable solution be found to provide a fully sustainable, permanent commercially-viable. maintenance and support programme.
- The Dissemination and roll-out activities significantly exceeded the targets (by a factor of two or more).

A view of the solar panels on the Seeta tower Anchor site. The South oriented panels are nearest the camera & the North oriented panels in the background

Specifically:

- We completed a stand-alone solar/battery back-up generator power system (**Anchor** site installation) at cell phone site at Seeta in April. The installation took only 12 days from placement of contract to completion, which I exceptionally fast. The system has run without any interruptions 100% up-time versus the tough target of 99.98% uptime. Diesel use has fallen by 92-95%.
- A solar/battery power system has been installed to provide drinking water to the village (**Community facility**) and to pump further water 20 metres up-hill to be available for drip-feed irrigation to the most fertile fields some 500 metres from the borehole (**Business** application). The pump and solar/battery power system) has worked flawlessly from commissioning.
- We deployed 54 solar home lights to the villagers all on a pay-as-you-go basis. All the systems continue to work.
- We completed 7 major and 10 minor dissemination activities[1], more than doubling the target.
- We submitted 10 applications for follow-on funding totalling $41m based on a business model which was refined using data from this pilot project. This more than doubled the target of 4 applications totalling $20m.

3. Engagement with Stakeholders

Engagement with stakeholders fell into two separate, but related activities.

1. Engagement with the telecoms industry, including phone operators; tower operators; equipment suppliers etc. Since the original proposal was to co-locate the anchor and village components of the AB-D model, this predated the village engagement
2. Engagement with the villagers in the chosen village (Buwofu) and related stakeholders including equipment suppliers; local district Government offices; etc.

Meeting with the local farmers to discuss drip-feed irrigation

Engagement with the telecoms industry commenced during the contract negotiations and before the contract was signed as we all recognised this engagement would have a long lead-time. In all cases, the telecoms industry was enthusiastic with the prospect of replacing their diesel generators with solar power systems, to reduce issues concerned with high costs of diesel fuel and maintenance; low reliability; theft of fuel (and hence security issues). These were somewhat tempered when we only had financing for a single site and no clear roll-out plan. We pursued 6 different options for site selection with different operators and groupings of stakeholders and in every case (except the last), initial enthusiasm was overtaken by whatever next engineering crisis hit them. Typically, negotiations were not

[1] For details see the Final (Completion) Quarterly Progress report on this project.

broken off, merely the staff were too busy to return calls, reply to e-mails and inform us that the project was no longer of interest.

We thus loosened the requirement that the tower and village had to be collocated (there had never been an expectation that the two sets of clients would be physically joined by a wire) and rapidly negotiated access to a site owned by the Government telecoms operator UTL, which was being used as test site by CPS for their diesel hybrid power plant. The site is called Seeta High. This one year trial was coming to an end, with some uncertainty as to how power would be maintained on site; removal of equipment etc. We negotiated a deal to convert the site into a primarily solar/battery site, retaining the new hybrid diesel power plant as back-up since the site was too small to provide complete independence of diesel. The new equipment and contract allows the site to be used and monitored for a further 18 months. The site had the attraction of being within 30 minutes of Kampala making it relatively easy to take visitors to the site, but the surrounding villages were on grid. Interestingly there are two cell masts located on the same site and the other one was connected to the grid. In spite of this, the costs of connection and the step-down transformer and the unreliability of the mains power argued in favour of the solar provision. (Strictly the economics slightly favour grid connection, but reliability and freedom of operation favoured solar.)

A range of solar home systems “on display”.

A key lesson learned about local engagement was that site access was strictly controlled with a single key being held by our telecoms equipment partner CPS. We believe this was critical. Diesel theft is endemic in Uganda and we deprived both thieves and possibly employees of UTL of a source of illegal payments. Had access been more freely available, it has been suggested that our equipment would have been sabotaged, forcing us back onto the diesel generator and re-establishing the “theft chain”.

Family ties are important in Uganda and so the village was chosen based on personal connections. Multiple meetings were held with the villagers (see photo) to explain what we intended to do and to get their input and buy-in to the programme. When the programme extended to include provision of drinking water as their aid funded hand pump had broken beyond repair, we helped the village set up a water committee to administer the water system. This was successful. We also ensured we used (and paid for) as much local labour as we could rather than importing labourers. We only brought in skilled technicians and the villagers were keen to learn from these staff members. This increased buy-in to the project and diverted resources to the local economy rather than spending the money in Kampala. We have had cordial relationships with the villagers throughout the process and believe that out stakeholder engagement was a success. Nevertheless, a number of lessons were learned:

The village headman introduces us to his villagers

1. Much more work is needed up front to counter a deep routed “free-aid” culture and move them to a more commercial mind-set.
2. Ability to deliver fast on contracts is essential.
    a. Companies seek contractors and suppliers with whom they can form long-term relationships over multiple projects. Cell phone operators are no longer interested in single pilot projects. They know the technology works and provides benefits. They want to roll-out major conversion projects.
    b. Once customers have ordered Solar home systems they want them delivered immediately. Long delivery times and large gaps between stakeholder engagements is the hallmark of “free-aid” and they respond as such.

3. A “champion in the village is a great help. We should seek to recruit, train retain and provide an entrepreneurial income for an agent as soon as we engage with the village. However, fast fulfilment on logistics is essential to provide fast earned income and manage expectations.
4. Some training or sensitisation is needed for the villagers to optimise the use patterns of their lighting systems to get optimal performance.

The children were especially attentive. This is their future!

4. The Activities

This project demonstrated the full A B C+D model in Uganda.

- We upgraded a diesel generator hybrid power system on a (fully functional) test site to a near pure solar hybrid system. This **Anchor** installation was completed in an astonishing 12 days from placement of order to fully operational site, demonstrating the power and effectiveness of excellence in logistics and planning. Credit is due to our partners Cambridge Power Systems (CPS).
- We installed a water pump and solar battery system to Buwofu. This system replaced a broken had pump installed by a charity and which did not have the resources to repair it. It pumps water from a 39 metre deep borehole to a tank situated close to the village and which supplies water via 4 taps (**Community Facility** use of power). Each household pays a fixed monthly payment for water. It also pumps water 20 metres further up hill, to the most fertile fields situated 500 metres from the borehole (**Business** Use). Farmers will be charged for the use of water for drip-irrigation.
- We demonstrated and “sold” 54 **Domestic** solar lighting systems on PAYG payment plans in the village exceeding the target by 4 units!

Work underway to install the solar power system at the Seeta cell phone tower. Grey boxes to the left hold the batteries and the white boxes in the background are the outdoor radio cabinets.

The water project was particularly challenging. The initial concept was to hand-dig a well near the fields for drip irrigation (Business Use), given the distance from the drinking water borehole and the concerns over sharing drinking water for irrigation and replacing a simple hand-pump with a more complex solar pump with the attendant risk of failing to provide a life-giving basic commodity (clean drinking water). A lack of accurate hydrology data and concerns over time to obtain water extraction permits put this plan at high risk of not delivering within the project timetable.

At the next stakeholder meeting with the villagers, it was noted that the hand pump had failed and villagers were again turning to a contaminated water seepage for drinking water, with the women and girls spending longer filling the water drums, carrying the water over longer distances and crucially up-hill (the men-folk did not lend a hand). Faeces were observed close to the water source and within the radius where women were working to collect the water.

Immediately, we paid for a full survey on the pump with the full consent of the village. The hand pump was corroded beyond repair, the voluntary water committee had long since stopped savings for repairs and the charity could not be contacted.

High efficiency solar water pumps operate without batteries and are directly connected to the PV panels, reducing costs and complexity. They are designed to maximise use of available power, pumping slowly at dawn and dusk and at full speed in the middle of the day. They assume “unlimited” availability of water. Unfortunately, tests of the borehole showed it had a maximum flow rate, necessitating us to allow 16 hours of pumping at the maximum extraction rate. This meant we had to add battery storage (like the Anchor power system design) but then limit the power out so as not to exceed the maximum extraction rate. Finally, we needed to supply water to two tanks, one high on the hillside for the field irrigation and one next to the borehole for the drinking water supply, which meant the power system had to provide two different power

levels, sensing which tank required filling and yet not pumping faster than the borehole would permit and draining the well, which would in turn damage the pump.

Our team solved the design issues, but found the local stockists (two) would not supply the pump (nor install it) under such a novel design. The manufacturers in Germany confirmed our design did not invalidate the warranty, and was within design specification. Because of the novelty of the design, their engineers were enthusiastically supportive, although some of their designs got lost in their own complexity. We needed a simple African solution – not an over engineered German / European design! Once again our partners overcame the doubters by testing the new design at their workshops in Kampala, and learned enough from the suppliers and the tests to undertake the fitting of both the pump and the power system in the village. This had a further advantage in that the installation at the village was cut from five days to two (which included the preliminary commissioning activities). The villagers were impressed at the speed and efficiency of the private sector workers and contrasted this with the time taken to install the charity donated hand-pump.

Clean, safe drinking water returns to the village.

5. Outcomes

All the solar systems remain operational and are performing to their design specifications.

Upper end of the entrenched pipe leading from pump to the stand for the upper reservoir for the irrigation. The most fertile fields were situated 500meters distance and 20 metres higher from the borehole

The anchor system is fully remotely monitored and has been delivering power with zero unplanned outages for over 8 months. (Note power suppliers and diesel maintainers face heavy contract penalties if cell phone uptime falls below 99.98% availability in any months equating to more than 10 mins loss of power (or radio failure). Further penalties are imposed if the system is not responded to within 2 hours and repaired within 4-6 hours. (The actual service levels are site dependent depending on how critical the site is – the numbers shown are typical.) This has (partially) overlapped with the two (major and minor) rainy seasons in Uganda, when solar is under the greatest stress to provide continuous power. Diesel usage has fallen by about 95% to about 3-8% of that consumed when it was a pure diesel site. The only technical issue has been that the monitoring system lost data for 2 week, but we have confirmed with the operator that there was no loss of service, as the monitoring system is independent of the site controller.

The water system has only just been commissioned but has functioned exactly against the design specifications. At the time of writing it had performed flawlessly for one month again with zero outages. However, water use is currently lower than predicted and so the design has not been pushed to its design limits as yet.

None of the solar lighting systems have failed (they are warranted for a year). We offered various designs with different levels of functionality and duration of power. The lowest level (least expensive) option was favoured. All systems offered cell phone charging and lighting functionality.

However the least expensive option has only sufficient power to charge a cell phone OR provide light at full power for 6 hours (or half and half). Initially, the users continued to allow their phones to fully discharge, as they were used to paying per charge and they needed to travel to the town for this (paid) service. (This also reduces the life of the battery). As a result there was insufficient power left in the system to provide adequate lighting at night.

Once they realised they could and were better off recharging every day, then they could both provide the necessary partial recharge to full capacity and have adequate evening lighting without purchasing a second system. Furthermore, the (remote) dimmer function allowed them to choose between fewer hours at full brightness and longer duration at reduced brightness. Contrary to some incorrect popular beliefs, partial

recharging to full every day has an added benefit in that it should extend the life of the battery as measured in years and months.

6. Impact of the Project

Lower end of the entrenched pipe from pump (and drinking water tank), leading to upper tank

- The project to date has reduced CO_2 emissions by about 50 tonnes per annum[2], with 31 tonnes being saved during the actual project deployment.
- 50 households (out of 120 in the village) now have solar light and phone charging capability each saving an estimated $42 per household. Although this seems low, many of these villagers are near or below the poverty line, so this represents a 10% savings in household expenditure.
- The almost immediate penetration rate of 45% was higher than expected. Our business plan assumes 30% penetration over an 18 months sales campaign.
- We provided temporary employment to about 10 villagers, providing a temporary boost to the economy.
- The drip irrigation scheme is anticipated to provide an increased income, based on tomato production. The water system is sized to provide irrigation water to 2 such sized plots, However, current water draw for drinking water is well below half of the anticipated volume and the drip feed water estimates were based on the maximum potential draw, and so a further 1 – 2 quarter acre plots may be viable. With the addition of further solar panels and batteries (comparatively marginal cost), there is sufficient water flow from the bore hole to irrigate a total of four quarter-acre plots.
- The above extra income will have a marked impact on the village economy.
- We provided employment for a skilled country manager for about 6 months of the project, and expect to extend this employment for at least a further year. If funding can be found to extend this pilot into a full demonstration project, this employment may become permanently sustainable.
- When we started work in the village, the villagers had access to safe, clean drinking water. During the project the charity gifted hand-pump broke down, beyond financial repair and water was drawn from a contaminated surface seepage, with a significant potential to catch and spread infectious water borne diseases. Had cholera come to the village, it would have spread like wildfire.
- This project replaced the ready access to clean water, with all the associate health benefits. Furthermore, although the women and girls still fetch the water over the same distances, we have eliminated their manual labour associated with the water pump, freeing up time.

7. Monitoring Plan and Next steps in Uganda

Both the cell phone (**Anchor**) site and the water pump power system (**Business and Community Facility**) are (or will be) fitted with automated remote monitoring systems. Africa Power will commit to continue to operate, monitor and maintain these systems with the results being made available to CDKN in the Project Impact Review in mid-2017. We will continue to visit the village and provide warranty support to the lighting systems and informally monitor the impact of the village power impact on the village.

UTL the Government owned cell phone operator continues to have major financial problems. It is primarily owned by a Libyan based financial company whose financial assets are frozen, thus adding a few more tower to our portfolio in Uganda is not economically viable and major funding (>$5m) will be needed to be able to provide a sufficiently large installation programme to attract the attention of the other operators. Unfortunately our application for NAMA Facility funding for Uganda was turned down on the basis that although they are seeking projects applications from the private sector, they were unwilling to have the majority of the funding being allocated to the applicant.

[2] Calculation based on householders saving half the kerosene use before. The solar site is compared to a diesel site using 16,000 litres per annum

A view of the solar / battery powered water pump site. The PV panels provide shade for the battery box below. The borehole is between the batteries and water tank

Africa Power, and its directors, however remain committed to supporting this project in Uganda for a further trial period of one to 2 years. One of the directors splits his time between Kampala and London and is especially committed to building businesses and supporting Uganda's growth. Two directors own a computer installation company in Kampala (TrainAfric) focused on educational establishments (schools, colleges and universities) and have the exclusive distributorship to very low-powered solar ready computer systems drawing less than 10% of the power of a conventional desk top PC and with comparable performance. Clearly there are potential synergies between this "sister" company and Africa Power as an off-grid rural power company.

We will exploit these synergies and by drawing on support from TrainAfric and with the gift of free time by the directors, we will seek to exploit the knowledge and contacts gained to build a very small business and retain our country business manager in gainful employment. The main concentration will be on

- Extending PAYG solar home systems into nearby villages
- Acting as an importer and distributor for solar lighting systems, providing better logistic support and indeed better products as lower prices as identified in the project.
- Seek to provide smaller business systems (other than the drip-irrigation model) on a PAYG basis

Whilst it is possible that with free support from TrainAfric and the directors, a small business may be grown organically from the small pilot basis provided by the project, the main objective is to maintain an ongoing business, whilst efforts are made to find funding to grow the business. Approximately $0.5 to 1.5m funding will provide a small, growing business to maintain the knowledge, provide continuing employment and act as a test bed for further innovation. $3-5M will enable the business to expand and make a real and lasting impact on rural electrification in Uganda, providing power to about 200 villages and bring the benefits of electrification to 100,000 people over 5 years and half a million over 10 years.

8. Dissemination

After initial excitement, water collection reverts to the women and girls.

The dissemination activities were particularly successful and exceeded the project plan by a factor of 2-3. The target was to disseminate the knowledge gained in 4 major events or presentations. We actually presented at 7 major and 10 minor events[3].

Early opportunities to present at major events, led to further invitations throughout the year. Contrary to our expectations of having to actively seek dissemination opportunities, we received an almost continuous flow of invitations. In the end we presented the CDKN supported work at 7 major and 10 minor events – approximately one event per month. With each even typically taking up a day (including travel sometimes up to 2 or 5 days) and 1 -3 days preparation time, this constituted a major and successful use of the funded resources. The major presentations and events included:

- Africa Global Business Partnership Forum
- Zambian Government: REA and ZICTA – Multiple meetings
- Tanzanian Parliament Forum on Environment & Climate Change
- CDKN Presentation and Webinar: Thursday, 30th April
- Sida Workshop on DESCO's in Lusaka; 24th Sept – Keynote paper
- CDKN Rural power Workshop in Delhi

[3] We classified a major presentation as being a presentation at a major conference on Energy in Africa, being a key-note speaker at a smaller but focussed meeting on off-grid power in Africa or a major meeting with Government or funding bodies specifically directed at and helping to advance major funding applications.

- Presentation and private meeting with new Zambian Minister of Energy on off-grid rural power (also present: the Permanent Secretary; and Deputy minister).

Minor meetings include: DfID (Green Mini-grids); Ugandan Diaspora; KfW; Sida (Zambia and Tanzania); UK DECC (NAMA facility); Off-grid development workshop (Wajir - Northern Kenya); Africa Forum 2015 organised by the international law firm, Hogan Lovells; REA and MEM in Tanzania as part of the NAMA Facility grant application; Women and Power at COP21 in Paris.

For further details the final quarterly report[4].

Although some of these presentations were of general significance enhancing the "brand" and visibility of both CDKN and Africa Power, some of them had significant positive direct and indirect impact on leveraged funding opportunities (see section 9 below).

9. Financial Models for Implementation of the ABCD Model

The Anchor Cell Phone site installation confirmed the capital cost structures of our business plan, but demonstrated that the cost and time of installation and indeed lead-times could be reduced, providing both a small overall installation cost reduction and an improved IRR (Internal Rate of Return).

The cost savings per site compared to a diesel generator are very dependent on the power required at the site. The new models based on this pilot study show we can offer a 10-20% lower cost per months compared to diesel generators for the majority of sites with power demands of 1-1.5kW (continuous 24/7), with an improved up-time and the elimination of diesel theft, which has a major negative impact of cell phone companies CSR activities.

A new innovation in the cell phone industry has been the launch of very low power (500W) small remote village radio systems. Both the Tanzanian and Zambian Governments are financially supporting the build out of these systems to meet their target of providing cell phone access to over 95% of the population. Hitherto, these very remote sites were so far beyond economic commercial feasibility that even with Government grants these were unviable. The smaller solar battery system for the Water project allowed us to confirm our business models for these new remote sites and where we offer even better cost savings compared to diesel power.

The water project produced mixed financial models. It is uneconomic to pump drinking water and drip-feed irrigation water from deep bore-holes, even when the flow rates are adequate to dispense with the batteries to provide night-time pumping, and the cost of the borehole is paid by Government or Development funding. However, the models demonstrate that drip-feed irrigation remains potentially commercially viable when using surface ponds or bunds and even down to modest depths. The depth limit is expected to be about 10-20 metres. It is clear that water projects remain a specialist area and successful implementation will require partnering with companies specialising in water and irrigation, and where Africa Power focusses on the power and pump aspects, with the water company focusing on water sourcing (including all the relevant permitting; sinking of any boreholes or wells and the productive end-use.

Simple low cost solar lighting system. Note the USB cell phone charging port

The biggest revision of our economic models came about with the Domestic Solar Lighting systems. Our prior model was to offer single product comprising a 6W solar panel, batteries, two 100-150 lumen light and a single cell phone charging port and charging $1.50 per week for 18 months representing a potential 60% savings on the costs of kerosene and candles. We envisaged some form of upgrade path, such that households could upgrade their systems to a larger system with more lights, radios, TV's fans and maybe even a fridge over time and on an affordable plan, and indeed a number of suppliers suggested they had an "upgradeable family of products".

The pilot project taught us a number of key lessons:

- One size does not fit all. We see the need for a range of products:

[4] CDKN | Testing Synergies in Distributed Renewable Village Power - | AAGL-0047b | 22nd December, 2015 | 5th Quarterly Report

- Addition of a level zero (non-upgradeable) PAYG solar lantern comprising a single portable light; 3-5 watt panel and one or two cell phone charging points, and costing $1/ week to purchase over a year. This is the genuine pro- (very) poor business model. Such systems are available, although a small increase in the brightness of the light and a modest increase in solar panel size from 3.3 to 4-5 Watts is desirable and will come in the next generation products. These systems will significantly reduce kerosene consumption, but not eliminate it.
- The level one product should be up-grade-able. Our new specifications are for 3 lights (the main one being 300 lumens; and two further 200 lumens lights), and two cell phone charging outlets. The SHS will be powered by a 10W PV panel mounted (permanently) on the roof and the system will be fully wired into the house with local switches, etc. Level one SHS are just becoming available on the market at our required price point (but were not available for the trial) but are not upgradeable.
- Level 2 is a 30W SHS adding a selection of small appliances such as: a fourth lamp (typically added as a security or courtesy lamp), smaller potable solar study lamps; radio and music players; fans. This upgrade will cost the same amount per week and complete in about 1 year.
- Level 3 add the TV to the solar home system. The weekly payment is maintained, but take 2 years to pay off.

- Distributors and whole-sellers have limited or zero spare stock in country and lead times for products are slow and they charge a premium for faster delivery.
- Most of the current PAYG systems are being manufactured by companies which have set up their own SHS companies. In general they do not offer competitive wholesale pricing taking their profit in manufacturing rather than deployment.
- The current PAYG suppliers are generally moving up-market seeking to supply larger systems (many with TV's) to the wealthier villagers, leaving the poorer households without solar opportunities.
- The market is however evolving rapidly with some 20-30 new entrants into the PAYG market. Many of these are manufacturers without sales channels and their distributor prices are much keener
- Low power TV's are just being developed suggesting TV's can be offered with a level 3 package, instead of level 4 or 5 previously. This makes them seem much more within reach and should provide a major impetus on sales.

We are working to develop a Graduated family of PAYG Solar Home systems and expect to apply for R&D funding to develop these systems. A key development goal is to create a genuine pro-poor family of SHS allowing every house hold to reach full electrification over time and an affordable plan. The price of this plan must be (substantially) lower than the weekly current spend on kerosene and candles.

Whilst these new products will underpin the Domestic Solar Home part of the ABCD model, we will also offer these at competitive wholesale prices to other companies supplying off-grid rural Solar Home Systems to ensure the benefits of solar power can reach everyone and increase rural electrification rates from the current miserly 10% to 80% in 20 years.

10. Leveraged Funding and Future Opportunities Emerging

The main driver for this project was to provide a pilot demonstration of the ABC+D concepts, gathering the relevant technical and business information to develop a business plan and seek funding for either a further demonstration programme or to roll-out the concept in East and/or Southern Africa.

A key task was thus to

- complete at least 4 development grant applications totalling $20m of funding.

Development funding is notoriously slow in being assessed and contracted. There were thus no targets to have such funding under contract by the end of the project, but the CDKN Objectives form has a target to:

- win at least $10m funding (and commence or extend operations) in at least one country by December 2016.

This grant application task was exceeded by at least a factor of two with

- 8 applications being completed (at a rate of one per 2 months) totalling $41m in requested grants

More importantly, we were notified that we had won an AECF REACT3 grant for a $1.5m repayable grant (subject to obtaining co-funding) and are using this funding to leverage further funding for Tanzania.

Inevitably some applications were rejected. The most common reasons for rejection are that the funds will only fund on a project basis rather than via what is essentially company financing or that the reviewers believe the project is too ambitious and do not recognise the speed with which companies can grow once commercial funding is available. That, in turn, requires a 2 year proven track record and a (near) profitable business.

Other applications are at an earlier stage and we are hopeful these and new applications based on this pilot project will have gradually have a greater funding rate as the model is gradually proven in Uganda and Tanzania. To that end, the AECF REACT3 funding includes a complimentary programme to help the recipients expand their funding. The kick-off workshop will be held in Nairobi in February 2016.

The ABCD Business Plan is based on a new approach to rural electrification and is based on 7 key principles:

Africa Power's ABC+D Business Plan – a New Approach to Rural electrification

1. **Use independent distributed systems to deliver cost effective, tailored solutions**
   - Exploit changes in the cost and performance of distributed generation rather than use a "one-size fits all" mini-grid, thus avoiding the upfront capital cost associated with the grid connections.
   - Install the power generation which matches the need, thus reducing waste and excess costs
   - Address concern that mobile and tower operators do not want community power system physically connected to their infrastructure
2. **Deliver distinct services to meet needs of different market needs and different customers**
   - A-B-C-D model adopted and extended for different types of customer
   - Competitively priced, highly dependable power for Anchor businesses
   - A technical and economic solution to meet the needs of each B-C-D customer
3. **Provide all services on a "Pay-as-you-go" basis to remove key barriers to adoption**
   - No upfront capital investment and no or only small deposit from any customer
   - Africa Power owns the equipment and then provides the service for a weekly or monthly fee
   - Provide solutions to small business; community and domestic customers which include the productive end-use equipment such as fridges, pumps, lighting, chargers, etc.
4. **Share support services across customers to reduce costs and increase reliability**
   - Skilled installation and maintenance teams make regular site visits to support key Anchor clients
   - Use same teams to support B-C-D customers at lower cost than dedicated support teams
   - Work with local entrepreneurs and others already present in the community to provide other services and support (e.g., installation of low voltage systems and collection payments for individual households)
5. **Combine commercial and grant financing**
   - Access both commercial finance (based on the economics of our anchor tenants) and development finance (because of the development benefits of community power)
   - Reduces overall risk and cost of capital for investors, and increases their returns
   - Commercial approach provides an immediate and substantial multiplier for any grant investment and ensures long-term business viability and continuing maintenance
6. **Provide complete power solutions**
   - Provide both the power system and the end-use equipment/appliances to make productive use of the power. By specifying high quality, high-efficiency equipment, we lower the cost of the service (lower life-cycle costs)
   - By matching the power to the load we achieve higher load factors reducing capital costs
7. **Value Proposition:**
   - Each system is priced so as to provide either (A) a **saving over the current cost** of provision of the services Or (B) an **increase in profits** from a new or expanded business without Government subsidies or feed-in tariffs, etc.

Healthy drip feed irrigation plants

The latest teasers and business plan are available for validated potential investors and funders under appropriate non-disclosure agreements because of the business sensitive information therein. Please Contact alivesey@africapowerltd.com if you wish further information.

11. Project financials

Total project cost:	£132,218
Total billed:	£132,218
Breakdown of project costs	Fees: £99,857

	Expenses: £32,361 Total: £132,218

12. Appendix 1: Lessons Learned

A separate (public domain) whitepaper has been completed and is available from the Authors or CDKN.

13. Appendix 2: Typical Roll-out Business Plan Teaser

We have provided a typical roll-out Business Plan Teaser as a separate pdf file. This document contains commercially sensitive material.