Development of a 'pay as you go' solar home system

In Rwanda, as in all developing countries, most people living in rural areas don't have electricity. There are many proposed solutions to this problem but all have their disadvantages. One lesser researched and commercialised solution is a household off-grid solar system which is sold on a 'pay-as-you-go' payment plan. Ashley Grealish reports on the trial project he set up with e.quinox.

First generation izuba box used in the 2012 trials.

Credit Ashley Grealish

e.quinox is a non-profit student-led humanitarian project that aims to bring cost-effective, sustainable and renewable energy to developing countries. e.quinox aims to prove that certain business models and technology can work thus encouraging the uptake of these models by for-profit organisations.

During 2012 e.quinox developed the first prototype of the household off-grid photovoltaic (solar) system which is currently being used in a trial of 75 units in Northern Rwanda. These units are named the izuba box (izuba means solar in Kinyarwandan) and are simply a battery which can be charged with solar panels and allows the user to power lighting and charge mobile phones. The product integrates a system to manage the payment on a 'pay-as-you-go', hire-purchase model.

Many people would argue that a commercially viable 'pay-as-you-go' solution cannot be used to provide electrical light as the target customers do not have the money to support a for-profit venture. This however is not true, and e.quinox intends to prove it.

The market currently spends $37 billion on low quality energy solutions. This is a potentially huge market if businesses change their models so that the poorest of customers can be reached. Poorer consumers cannot afford to pay large amounts of cash for a product and are much better served by small, frequent payments. For example, shampoo is often sold to these markets in single use sachets rather than large bottles allowing the price sensitive consumer to purchase just what they need for the day. By applying this methodology to electrification, for-profit companies would be able to deliver their products in a sustainable and large scale way.

The creation of the izuba box, which is e.quinox's 'pay-as-you-go' solution to the problem, was developed from their previous work on energy kiosks and solar home systems.

Previous projects have seen e.quinox build six energy kiosks in Rwanda and Tanzania since 2009. The energy kiosks are small buildings built at the centre of a village with solar panels, which are used by a shopkeeper to charge battery boxes. Customers rent a battery box, which consists of a sealed lead-acid battery with protection and power level conversion circuitry, allowing it to power LED lighting and charge mobile phones. Customers will rent a fully charged battery box, take it to their homes and return it when the battery is depleted.

However, during the trials of the energy kiosk model many issues were identified. These issues were improved upon in the creation of the izuba box. Firstly, the izuba box removes the central kiosk and extends the battery box to incorporate power generation facilities; each box is supplied with its own solar panel, charge controller and payment system. By removing the central kiosk the cost of building, maintaining and operating a central kiosk is removed. Customers pay weekly for the use of the izuba box and it will automatically lock after a payment has expired. Payment is made using a mobile phone based money transfer system which is already widely used in Rwanda and surrounding countries. Money is transferred to e.quinox from the customer and they receive a SMS reply with a unique unlock code for their system.

One benefit to the customers is that the izuba box is charged and paid for in the user's home meaning that the time previously spent travelling to gain access to electricity is now freed up. The kiosk system is not appropriate in rural villages with sparse populations. Villagers may have to walk for five hours or more to rent a battery box in the closest large village. Although customers may still need to travel to top up their mobile money credit, mobile phone networks already have very good distribution networks in place for this.

The izuba box is very similarly priced to other solar home products, provided commercially by companies such as Bboxx and D.Light. The addition

of the pay-as-you-go system however makes the product affordable to almost all customers. The monthly cost to consumers, based on a two year payback period, is less than the average poorer consumers' spend on low quality energy solutions, such as kerosene lighting. This is an advantage for customers because it is more affordable; however it could also be beneficial to for-profit organisations. By incorporating the pay-as-you-go systems, for-profit organisations would be able to reach even the poorest customers, rather than just selling more expensive products to richer but fewer consumers in developing nations.

Using the kiosk model, there are also problems with bookkeeping and management. In each kiosk e.quinox employs a shopkeeper who is paid through the profits generated. They are in charge of keeping track of the finances and ensuring all customers have paid for their rentals. However hiring shopkeepers who are educated enough to maintain the accounts and the technical aspects of the kiosk is very difficult due to the lack of education, and occasionally corruption creeps in. When analysing performance of each kiosk e.quinox members often find the accounts to be so badly kept that the data is unusable.

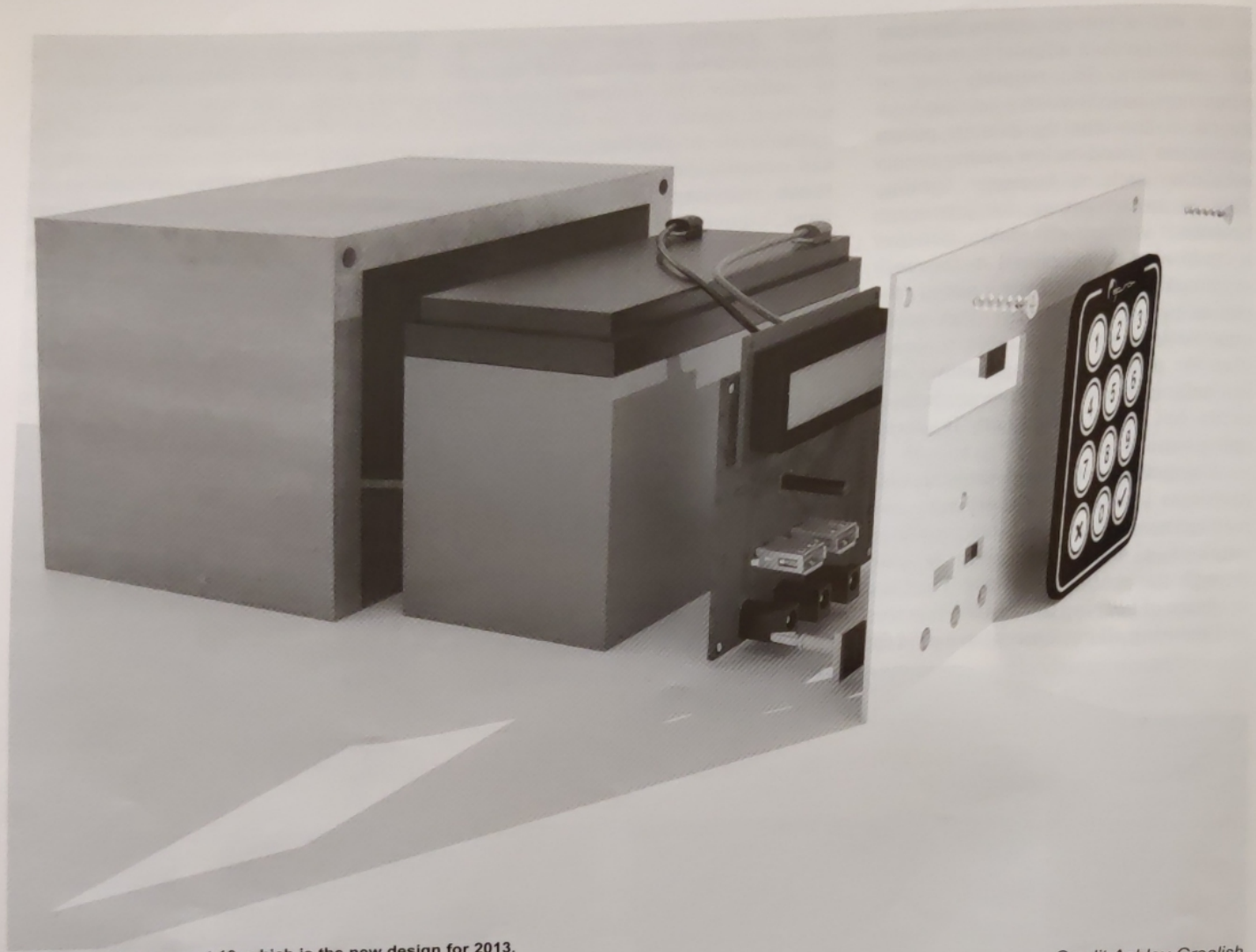
The kiosk also needs to make enough profit to pay the wage of the shopkeeper otherwise e.quinox faces long term losses. Therefore the kiosks need a minimum number of regular customers for it to be sustainable. Not only do the kiosks have a minimum level of custom, they also suffer from having a maximum level too. This upper limit is a technical limit as the equipment we can supply can only generate a limited amount of power, especially in the wet season.

The shopkeepers did prove beneficial when distributing the 75 prototype izuba boxes. They helped us to focus on the bottom income group in rural areas. The test customers were known to the shopkeeper at one of equinox's existing kiosks, which allowed good quality feedback to be received from trial participants. It was thanks to this that we managed to identify many issues which need to be addressed before the izuba box can be deployed on a large scale.

The main issue found with izuba box was the third party charge controller which was used with the boxes (a charge controller limits the rate at which electric current is added to or drawn from electric batteries, and prevents overcharging). The charge controller used is the most basic type and leads to a short life of the battery box. e.quinox estimates that the batteries used in the first generation izuba box will fail before the end of the payback period. Consequently, we have covered the cost

Ashley Grealish displays the izuba box

Credit Ashley Grealish



Izuba box casing concept 10, which is the new design for 2013.

Credit Ashley Grealish

of replacement batteries in the total price of the unit.

The problem of the charge controllers has inspired me to find a solution, which I am currently working on as part of my Masters Degree at Imperial College. I am working to incorporate an intelligent maximum power point tracking charge controller into the current izuba box design. The new charge controller will allow full utilisation of the solar panel and ensure a replacement battery is not required during the product's lifetime. The aim is to increase battery lifetime by 300-400 per cent over the current design. The integration of the payment system and charge controller is beneficial as many components are duplicated when separated. Both systems require a method for detecting battery charge and switching of the outputs when battery is low. By integrating these systems together we reduce costs and increase the intelligence of the overall system.

The charge controller designed during my project will be optimised for a low cost pay-as-you-go solar home system. However the underlying design will be a low cost, high efficiency and battery-lifetime-optimising charge controller. This means that the design will have the potential to be used in many other applications.

One such application is street lighting; solar street lighting has gained much attention recently as a method for reduction of council spending and carbon footprint as well as for improving cities in developing nations. This gives my project an importance at home and in helping developing countries.

The final product design of the izuba box will be trailed in Rwanda in summer 2013 by an e.quinox team. The results of this trial will influence our future direction and we will promote what we have learnt to any interested parties with the aim of encouraging commercial organisations to deploy similar technologies on a large scale.

The project Ashley Grealish is working on is an Engineers without Borders affiliated project working to improve the design of an open source pay as you go solar home system developed by e.quinox during 2012

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