Annex Three

1. Paper submitted to World Renewable Energy conference in June 2000, Brighton. Design Development and Marketing of Solar Lanterns - Kieron Crawley, Ray Holland, Stephen Gitonga. This paper was presented with the best paper award for the conference

2. Africa's Midnight Sun. Article appearing in New Scientist on 22nd July 2000

3. Article appearing in Daily Nation Newspaper in Kenya on 24th February 2000

For more details of other papers and press articles about the Glowstar, please see the ITC Glowstar website at http://www.itcltd.com/glowstar

Design Development and Marketing of Solar Lanterns

Kieron Crawley, Ray Holland, Stephen Gitonga

Background

In many parts of Africa people who live in rural areas have no access to electricity. Despite ambitious government plans, the constraints imposed by a scarcity of financial resources and the sheer practical difficulties of transmitting and distributing grid electricity over huge areas means that most people face the prospect of going without a connection for many years to come. As a result, most families are forced to rely on candles or Kerosene lamps to provide basic lighting in their homes. In Kenya 96% of householders use kerosene for lighting, while 70% also spend significant amounts of hard earned cash on dry-cell batteries for torches.

Successive studies have highlighted the potential for decentralised supplies of power for lighting at both community and household level, and advances in Photo-voltaic technology has resulted in the steady growth of sales in Solar Home systems over the last few years. Unfortunately the cost of installing even a moderate Solar Home System puts it out of reach of the majority of rural families in developing countries.

A recent World Bank survey carried out in Kenya pointed to the potential for solar rechargeable lanterns as a low cost and flexible lighting option for large sections of the rural community. The project identified seven existing lantern designs considered to be appropriate to the African environment and used between thirty and sixty of each (all imported to Kenya) to test customer demand for the products and to collect feedback on the technical performance of the samples. While the study demonstrated that there was a real demand for Solar Lanterns, customers highlighted a number of technical shortcomings with all of the products tested. Most of these shortcomings related to the poor construction of the lanterns, the quality of light and the relatively sharp drop off in performance after a period of months of use.

Why has an effective Lantern not been developed by the Private Sector in developing countries?

For manufacturing companies in developing countries, new product development for local markets is expensive and risky. This is particularly true when the product is targeted at rural mass markets where effective marketing and distribution techniques are still unproven.

Not only may the company have poor access to technical know-how, but the long term capital investment required for mass production tooling makes it an unattractive option compared to products for smaller but more accessible markets amongst higher income groups.

On a global scale however, the potential for solar lantern products is huge (2 billion people currently without access to electricity) and the potential for a commercially viable product would seem to be great.

As a result of this analysis, Intermediate Technology Consultants were able to securefunding for a project to develop an improved lantern for use in rural households in developing countries. The main activities of the project were outlined as follows;

- using customer information as a starting point and working together with local manufacturers, provide technical “know how” to develop an improved lantern which meets all of the criteria demanded by customers,
- employ appropriate manufacturing and assembly techniques that would allow the product to be manufactured and assembled easily in developing countries,
- incorporate within the project a facility to overcome the constraint associated with capital outlay for mass production tooling,
- provide assistance with local marketing of the product using rural mass marketing techniques currently being developed in countries such as India through organisations such as International development Enterprises (IDE)

As a result the IT Solar Lantern has been designed as a low-cost alternative to a Solar Home System and is intended to allow rural African families to climb the first step on the “energy ladder”.

Structure of the project

The project has been broken down into a number of stages, of which one to three are now complete;

1. Customer Research and product specification
2. Design and Development
3. Prototype production and household testing
4. Selection of manufacturing licensees
5. Tooling and setting up for production
6. Marketing

Progress so far

Customer Research

Market research which is carried out in countries of the south must take careful account of peoples lifestyles and cultural backgrounds. This is particularly important when dealing with communities in rural areas where conventional research techniques can easily fall short and yield inaccurate results.

Bearing this in mind, a number of studies have been carried out in Kenya by project partners Energy Alternatives Africa. These have attempted to identify which aspects of existing Solar Lantern designs are favourable to potential customers.

During the Lantern survey, focus groups were used to measure reactions to particular design details. They were also used to stimulate more general discussions where participants could air their viewpoints and develop their responses. Detailed results from question and answer sessions were recorded on paper while more general feedback from discussion groups (which often contained interesting and unexpected information) was recorded on tape for analysis later.

As well as gathering important design data, a number of interesting lessons have been learnt which may serve as important pointers in future surveys of this type.

The team discovered that survey groups which were well balanced, helped to engender an atmosphere where everyone felt comfortable about having their say. These groups tended to yield more accurate results than those where the discussion was dominated by a few knowledgeable individuals.

The location and time of day for group surveys was also important. Holding a survey after dark might at first seem to be the best way of demonstrating lanterns and their important characteristics to customers. In practice the team found that in rural areas with no street lighting, finding participants (women in particular) who were willing to travel from home at that time was more difficult.

The team also discovered that although participants drawn from slightly higher income groups are easier to access and interview, their spending patterns can differ from those of customers from lower income households at which the new products might be targeted.

Product Specification

As a result of the initial focus group study the project team were able to come up with a concise description of the “ideal lantern”.

The most important features were identified were as follows;

Service characteristics;

- The maximum price of the lantern should be no more than $75 if possible
- The lantern should provide light for up to 4 hours each evening.
- Customers should have access to affordable and readily available spares
- Customers expect an overall lifetime of the lantern of 6 years
- Customers expect a 12 months warranty for the product

Design characteristics;

- The lantern should give a 360 degree spread of light,
- The bulb enclosure should allow maximum transmission of light with minimum dispersion effects.
- The carry handle should be sturdy and comfortable.
- The preferred choice of bulb was (5w CFL type)

- The lamp should be portable and weigh no more than 2.5 kg.
- The lantern should be stable with a good base.

Some of the extra features that potential customers expressed a need for were;

- An indicator to show that lamp is charging,
- A warning light to show that the lamp is about to switch off when the battery is low,
- A power socket to allow a small radio to be connected to the unit.

The findings of this initial survey were used to form a design brief and as a result, the team produced a new design for a lantern which incorporates all of these features.

Manufacturing Options

There are a range of options in terms of manufacturing techniques that are available to the designer today, and the choice of the most appropriate comes down to considerations of scale of production and cost. As a general rule, individual component part costs come down as production levels increase. This is usually accompanied however by a higher level of capital investment in tooling.

Injection moulding is a well established and cost effective technology for the mass production of household items in the North, it is becoming increasingly available as an option for manufacturing in developing countries where it is used in the mass production of basic goods such as buckets, basins, tableware and packaging.

High Density Polyetylenes and filed Poly Propylenes are relatively inexpensive and robust materials which can be recycled using simple equipment.

Considering the technical requirements for the Solar Lantern and the projected production quantities, injection moulding was selected as an ideal technology for producing low cost, high quality components with the level of detail required for this product.

Battery technology

A crucial component for any rechargeable device is the battery. The project activities have included research into available battery technologies to identify a battery which;

- has the capacity to store charge sufficient for the required period of lighting
- is suitably robust to withstand the heavy duty cycle required for daily charge and discharge
- requires no customer maintenance (also spill and leak proof)
- has minimum impact to the environment if disposed of at the end of its life cycle
- could be manufactured locally in the medium term in developing countries
- provides a cost effective solution

As a result a Valve Regulated Lead Acid (VRLA) battery with a gel electrolyte has been selected as the battery technology with which to prototype the lantern. Although this is available only through import at present, the project has established that with suitable investment the battery could be produced locally by manufacturers of traditional wet lead acid batteries.

Design and development - Rapid prototyping

It is vital during the development of any new product to show customers a sample and to listen to their ideas about it. This is especially important if fully-fledged production involves substantial investment in terms of tooling and machinery.

Until a few years ago designers could only produce “block models” of new injection moulded products. These were constructed by hand from wood and plastic and although they had the appearance of the final product they could not normally demonstrate any of the working characteristics. Today, computer aided design (CAD) software combined with rapid prototyping techniques and “soft-tooling” allow the designer to realise his new design in a matter of hours. A computer generated “electronic model” which contains all of the physical information about the size and shape of the new product is fed into a Rapid Prototype machine. The machine uses a filament of plastic and a moving nozzle to lay down

successive layers of material (rather like icing on a cake) which are built up to produce a plastic replica of the design. A soft silicon rubber mould, which is created by pouring liquid rubber around the original and allowing it to set, can then be used in turn to produce a small batch of products.

This technique allows the design team to assess the design very quickly and more importantly allows manufactures to obtain feedback from potential customers, all before any significant tooling costs have been incurred. This technique which is not normally available to manufacturers in developing countries has been brought to bear in the project through facilities at Coventry University and has been used to produce a small batch of sample lanterns for use in field trials in rural households in Kenya.

Prototype production and household testing

At the time of writing, thirty fully working prototype lanterns have been distributed to sample households where they have been used for a period of two months. Facilitators will shortly visit households and use a questionnaires to measure customers reactions to the new design. In addition, selected members from each household will be gathered together to form focus groups where information will be collected through more informal discussion about the lanterns.

Remaining work

Selection of manufacturing licensees - Investors prospectus

During the course of the project it has become apparent that the scope and potential for the Solar Lantern stretches far beyond Kenya. As a result the project geographical focus has been modified to encompass a number of other countries. The objective of this phase of the project will be to identify a number of regional centres where manufacturers are strategically placed to serve a number of high potential countries. Regions that have been identified so far are, Southern Africa, Western Africa, Asia and South America.

The Project team are currently working on developing an Investors Prospectus which will allow any potential manufacturer/distributor to assess the product in terms of the investment needed to commence local assembly and the likely returns in terms of sales to local markets.

Markets for new products in developing countries build up slowly and as a result manufacturers are naturally more cautious when it comes to investing in large production runs. It is likely that the project will facilitate the supply of component parts for lanterns to a number of manufacturers in regional centres. Injection moulding tooling held centrally in Europe or the Far East and funded by the project, will be used initially to supply mouldings in batches to licensed manufacturers who are interested in local assembly. As local markets are developed, tooling will be leased and transferred for local production of component parts.

For local manufacturer this removes some of the risk associated with setting up for large scale production and for the project it allows the capital cost associated with tooling to be amortised using royalty payments from licensees in a number of countries.

Quality control

Quality control is an important issue that needs to be addressed if a new product is to gain a foothold in the market and build reliable reputation. This is no less true in developing countries where the Solar PV sector has suffered as a result of the introduction to the market of poor quality amorphous panels. A product that is produced, assembled and distributed locally in more than one country presents even more of a challenge. By licensing manufacturers to produce and assemble lanterns locally using components and mouldings supplied initially from a central facility, the product holders will have an important tool with which to ensure that all lanterns meet minimum quality standards.

Lessons learnt so far

The project has broken new ground for ITDG in a number of areas and as a result has already produced a number of valuable lessons in development agency/commercial sector partnerships.

Commercial ownership and intellectual property

To ensure the success of the project, it has been essential at an early stage to involve potential manufacturers in the design and development process. This has thrown up interesting questions concerning commercial ownership and intellectual property rights. Ownership of a commercial product which has had design and development input from a number of different parties is potentially difficult to ascertain and agree upon. In addition, whereas development agencies are keen to disseminate and maximise the impact of their research, private companies have commercial interests which are focussed on maximising profit and protecting their share of the market. This can lead to problems when it comes the time for the technology to be disseminated.

With the Solar Lantern project, this potential hurdle was avoided by ensuring that all detailed technical input which had the potential to lead to an intellectual property asset, was carried out at arms length from the initial project manufacturing partners. These manufacturers although technically having no ownership of the resulting design, will be given first option to manufacture under license when the design process is complete. This ensures recognition of their input during the early stages of the project but provides the project team with the necessary flexibility and autonomy in selecting suitable licensees in other countries.

Development versus commercial interests

In the development sector the primary concern of agencies is to successfully deliver benefits to target groups (large numbers of poor people). In the commercial sector the bottom line is profit and continued growth of the business. In many instances these forces can work successfully hand in hand, and have real potential for mobilising change on a large scale. In projects which involve private sector/development agency collaboration, it is important however that these two goals are recognised and that there is a clear understanding of where they may cause project activities to diverge.

For products where there is a demonstrated demand across a variety of income level groups (eg. Solar powered lighting) the manufacturer has a choice in terms of pricing. A medium to high priced product will have a small market but will generate a relatively high margin and quick return on investment. These markets are generally easily accessible and are based around large centres of population. The same product, priced at a lower level will result in a lower margin but will give access to a much larger market with greater potential for overall profit. These markets are generally widely dispersed in rural areas and carry a larger risk in terms of return on investment for new products.

Whereas the latter generally contain the bulk of the beneficiaries targeted by development agencies, it is the former, lower risk group that manufacturing businesses are more comfortable in dealing with.

The marketing mechanisms needed to reach these customers are still being developed within countries of the South and the project has identified the need for a component which builds the capacity of local manufacturers to reach large rural mass markets through networks of rural marketing agents.

Conclusions

Work on the development of the Solar Lantern has generated a considerable amount of interest amongst potential customers and manufacturers alike. It is clear from the experience so far, that the unique position of development agencies such as ITDG can serve to bring together the necessary ingredients and partners for the development of new products for mass production within the commercial sector.

There are still many lessons to be learnt however surrounding issues of ownership and control of such products and the best models for working relationships between the development and commercial sector.

How does it work?

The Solar lantern kit consists of a Photo-Voltaic Panel, and a lantern containing a high efficiency lamp, a rechargeable battery and a charge control circuit. The concept is a simple one – during daytime, sunlight falling onto the Photo-Voltaic Panel generates a small electrical voltage. This is used to charge the Lanterns battery so that the lamp can provide light during darkness.

The charge control circuit housed within the lantern is the "brain" of the unit. Not only does it ensure that the battery is charged and discharged correctly so that it gives a lifetime of maintenance free service, but it can also "decide" to give the battery an extra top-up charge if the panel has gone without its full quota of sunlight for a few days. It's on-board microprocessor will even store information (which can be downloaded later after "interrogation") on how the lantern has been used over a period of time. This information is extremely useful and will help the designers build a picture of how customers use their lanterns. This information will be used to design better lanterns in future.

Africa's midnight sun

A simple solar lantern could change life for millions without electricity

DAVID WAIRIMU can finally do his homework. An innovative solar-powered lantern allows him to carry on working when it gets dark. "My position in class is much better since we got it," he says. David, who is 14, lives with his mother Margaret in a mud-walled hut in Engashura, near the town of Nakuru in Kenya.

Electric lights gleam in Nakura, but Kenya's ramshackle electricity grid does not reach 90 per cent of the country's homes, including those in Engashura. Until last January, the family's only light at night was a hurricane lamp burning kerosene. "It was too dark to read by," says David, who proudly displays his new hand-held lantern and points out the cable connecting it to the solar panel on their thatched roof. "We recharge during the day, and that provides electricity for an evening's light," says Margaret.

The Glowstar lantern is the brainchild of a British non-profit consultancy called Intermediate Technology Consultants. After trials in Kenyan homes, the lamp was launched commercially this month. The hope is that it will do for rural African lighting what the clockwork radio has done for its listening--provide a cheap, reliable, ecologically friendly product that does not require mains power, expensive batteries or kerosene.

The solar lantern kit, which costs around £70, is a purpose-built sealed unit containing its own rechargeable battery. What makes it unique is a new type of microchip charge regulator. Its designer, Kieron Crawley, says the regulator will be the key to its success, where other attempts to harness solar power have failed. Around 150 000 Kenyan households have tried using solar panels to charge up car batteries and run portable TVs and lights, but many have abandoned the equipment as batteries became exhausted owing to the use of poorly designed charging circuits.

ITC's microprocessor based charge-control circuit housed inside the lantern constantly monitors the battery to ensure it remains charged. At night it will switch the lantern off rather than allow the battery to go flat, and it can control how much solar energy is conveyed from the solar panel to the battery during the day. "Existing systems don't do this effectively," says Crawley. "As a result, performance gradually drops off and within six months the system is dead."

There have been teething problems during the lantern's pilot phase. "When the battery runs down the chip loses its memory and the whole thing has to be reprogrammed back in the UK," says Bernard Osawa of Nairobi consultancy Energy Alternatives, which has audited the pilot.

But Crawley is confident the problems have been sorted out. Few doubt that solar power has massive potential in rural areas of the developing world that are excluded from national electricity grids. After all, millions of children like David are waiting to do their homework.

Fred Pearce

From **New Scientist magazine**, 22 July 2000

Lantern offers cheap lighting alternative

A prototype lantern produced by an international NGO, which is being demonstrated in the outskirts of this Rift Valley provincial headquarters is shedding light on the otherwise dark nights of the area's poor. WANGULU ELIEZER reports.

Night studies have become an enjoyable experience for young James King'ori who attends Kagoto Primary School in the outskirts of Nakuru town, thanks to a new lantern that is being demonstrated in this area.

Ngashura area of Bahati division, where the lantern is being tested, does not have electricity.

"The lantern is so bright. It makes my night study enjoyable," say the standard six pupil who has taken responsibility of ensuring that the lantern is clean and kept safely.

Most residents of Ngashura area that is situated on the Nakuru-Nyahururu road, are ordinary peasants who cannot afford solar home systems or money required to extend electric power to their farms.

But now, there is light at the end of the tunnel as Intermediate Technology Development Group (ITDG), an international non-governmental organisation, endeavours to provide affordable lighting technology.

Already, 13 area residents have benefitted from lanterns that were designed by ITDG consultants in London.

"The lantern has an in-built battery that can serve for two years without any problem" Stephen Gitonga, team leader of ITDG's energy program, says. It has an extension lamp and an AC/DC charger.

Besides, each recipient of the lantern gets a solar panel that is used to charge the battery during the daytime.

Beneficiaries also get radios, which are powered by the lantern.

According to Lily Murei, project officer at Sustainable Community Development Services (SCODE), the 13 lanterns that were introduced in Bahati division last December are pouplar with the users.

ITDG has a working partnership with SCODE through which the latter distributes the lanterns. SCODE's technicians also install the 10W solar panels.

Says Don Redding, ITDG's public affairs manager "Solar home systems and electricity are beyond the reach of many people in Africa, Southern Asia and even Latin America. This is why ITDG consultants came up with this lantern. We hope it will be affordable" he said.

Demand for wood-fuel, which is most popular with urban and rural poor in Kenya is projected to rise to eight million tones of oil equivalent to 11 million tones this year. Electric power will thus remain beyond the reach of the majority.

Rural electrification is yet to be achieved in most areas because most people who are supposed to benefit from the scheme cannot afford to pay the required dues.

As a result, many rural and urban poor rely on wood-fuel or kerosene for both lighting and cooking.

Beneficiaries in the ITDG lantern demonstration area pay Ksh 7,500 to get the lantern and its auxiliary. Those who

cannot raise the entire amount are allowed to pay in instalments subject to a deposit of Ksh 1,500.

"The cost is well within the reach of the majority who cannot afford solar home systems. Most companies installing solar home systems are asking for an average of Ksh 50,000" Ms Murei says.

James King'ori's mother, Margaret Wairimu, 40 says the lantern is economical." I no longer budget for paraffin and dry cells," says the mother of seven. She said her lantern gives her six hours of lighting when fully charged by the solar panel.

However, the lantern gives her less hours of service if she uses it and the radio simultaneously. Mr Gitonga concurs, saying a fully charged battery will serve for five hours if used for lighting only. " The hours of service are reduced if you light and use the radio at the same time" he says.

However, the lanterns, according to Mr Redding, are prototypes and will be improved upon before mass production for a wider market. "We are interested in feedback from those who have acquired them before redesigning them and later manufacturing for commercial use" the ITDG public affairs manger said.

Redding said his organisation would look for a Kenyan partner to manufacture the lanterns. Besides addressing the energy requirements of the poor, the lanterns are also ideal for outdoor activities such as camping and picnics.

Currently the cost of manufacturing one lantern is US$ 50 to 70. It is feared that the cost of commercial production may force the price up, defeating the purpose of the invention – to serve the poor. ITDG would like the price to remain below Ksh 10,000 when commercial production starts.

Some beneficiaries feel the lanterns should be redesigned. "The lantern gives excellent light and can light a wider area. But there is a need to increase the duration of service" Mr John Njenga, a beneficiary says.

Other feel that the lantern needed a baton to show when the lantern's battery was full charged. The batons, they suggest, should indicate whether the lantern is on or off. This would be useful in charging.

"The problem with these lanterns is that you cannot tell when it is on or off. Most people have been charging them when they are on, only to allege that they are defective" John Omondi, a technician with SCODE says. Batteries should not be charged when the lanterns are on.

The lanterns are robust and are made mainly of thermoplastics. They are portable and can withstand hard falls. But most of the materials will have to be imported when local production commences.

Similar demonstrations are also being carried out in Machakos district. Mass production will start in May, and the lanterns will thereafter be available in retail outlets for Kenyans to buy. The lantern promises to be a milestone in the energy sector for it is set to illuminate the dim lives of the poor

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