Improving Rural Lighting in Developing Countries – Call for Action Among Lighting Equipment Suppliers

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ABSTRACT
Lighting is an important element of development: It facilitates education, allows productive use of time in the evening, and simply improves living standards. It has been estimated that some two billion people are without electricity, and thus also without access to modern light sources. It is not likely that many people will get access to the electricity grid soon, as population growth far exceeds connection rates. Little is known about peoples' lighting practices and wishes for upgrading current lighting services. This paper gives the results of field tests in 2 African countries where rural people were given an opportunity to purchase modern solar lighting equipment, and of a survey of 410 households that are already using solar electric or Photovoltaic (PV) systems. These surveys were carried out to identify rather than estimate people's lighting needs. Current traditional rural lighting practices and the experience with modern lighting are discussed. The outcome is surprising, and indicates a gap in available lighting equipment and a lack of interest on the part of lamp manufacturers. Implications for suggested research and development will be discussed.

INTRODUCTION

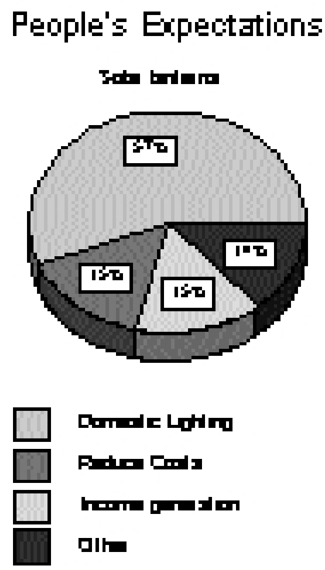
There is a real problem with rural electrification: Although enormous advances have been made over the past 20 to 30 years in several regions of the World, there are still 2 billion people without access to electricity. This problem does not seem to disappear under "business as usual" scenarios: In Sub Saharan Africa, population growth outpaces the number of newly connected households: between 1970 and 1990, the population with access to electricity increased by 55 million while the total population grew by 220 million[2]. Grid-based electrification approaches are capital intensive and for sustainability reasons demand a good return on investments. This can normally be obtained when the demand for electricity is concentrated in a limited area and is relatively high, which unfortunately is not the case in many rural areas of developing countries.

One of the promising alternative approaches is to use renewable energy technologies, and in particular photovoltaic systems generating solar electricity. Such systems can improve lighting conditions and provide access to radio and/or television, but initial equipment costs are still high compared with rural households' income. Therefore, the actual market for solar electricity is perceived to be small, and dependent on financially assisted programs. However, a few recent studies show that rural people actually spend a considerable amount of money on very inefficient energy supplies. What is more, choices people currently have to satisfy their energy needs are very limited. Rural households generally use kerosene wick lamps (often made of re-used food cans with an inserted cotton wick), hurricane lanterns, or candles to "satisfy" their lighting demand. Such lamps produce no more than 10–15 lumen for the locally made wick lanterns or 40–50 lumen for the imported hurricane lanterns [3]. In fact, most households do not use more than one light point in any one room at the same time: Doubling the number of lamps yields doubled costs but hardly any incremental lighting benefits. Light is used mainly to see contours and prevent people from bumping into each other or furniture. In addition, dry-cell batteries are used for radios and flashlights. Car batteries are often used to power appliances such as small black and white tv's, boomboxes, as well as lamps.

Combined costs of candles, kerosene and drycell batteries are often substantial: the World Bank through its ESMAP program [4], carried out surveys in several developing countries showing that households often spend as much as US$10 per month on those energy inefficient needs. As an example, monthly energy expenditures in rural Uganda (excluding costs for cooking energy) amounted to about $11, in Togo and Benin $7.7, in Niger $8.2, in Laos $5.0, and in Ecuador $6.6 [5], indicating that the ability to pay for more efficient electricity services could be higher than previously thought.

Better and more choices, combined with people's existing ability to pay opens up a possibility worth exploring: Private sector-based development of markets for solar electric equipment. Solar energy is already making its way into some people's houses, although in Africa only in Kenya, Morocco, South Africa and Zimbabwe on a scale worth talking about. Even then, it is limited to a few percent of rural households. PV equipment in most African countries is usually promoted through national programs or projects, and even in those four countries markets are only deciding to a limited extent what type of equipment is used. Whereas projects and programs often concentrate on complete kits [6], under a market oriented approach clients are likely to concentrate more on components: In Kenya, where solar electricity markets are further developed than in any other African country, a typical PV system consists of a PV module that often is added to an already existing electric household system based on a car battery. At the minimum, this would reduce the labor and costs for hauling the battery to town for recharging. Since solar electric systems are essentially modular, this approach is interesting as it fits households' expenditure patterns, and households can design their ideal systems over time. Solar lanterns will also provide much more light, in many instances ten times more than what people use now [7], and thus can be considered the first step up the modern lighting ladder. In fact, solar lanterns are actually the lowest-cost alternative for this purpose, but the up-front investment costs are still high. If a reliable solar lantern can be found in a developing country, it often costs in the range of $250 to $350 while for the same amount of money households can also buy a 12 Watt amorphous module, car battery, and a few lamps.

What is needed is to enrich the menu of options available to rural households, so that they will have more choices to satisfy their immediate needs for electricity, instead of waiting for the grid to arrive in their neighborhood. To that effect, the case can be made for lower cost solar lanterns to be developed, providing low-cost alternatives for households in the lower end of the rural income spectrum, and better and lower-cost efficient lamps for households in the middle and higher end of the rural income spectrum for use with small solar home systems. The following two sections give more information about the experience with solar lanterns, and with solar home systems under a market driven scenario in Sub Saharan Africa.



SOLAR LANTERNS

In order to learn more about the development of the PV market, ESMAP organized a test marketing program for solar lanterns in Kenya and Niger. Most solar lanterns are designed for the camping or weekend market in developed countries, and are expensive. What is more, they can hardly be found in Africa, and if they are, it is in one or two shops in the capital city. Households in developing countries need lanterns that operate on a daily basis, cost less than a basic solar home system, and can be found in rural area shops. The ESMAP project offered low-cost lanterns for sale in rural areas in Kenya and Niger, with a 6-month unconditional money back guarantee. A total of 320 (six different models) lanterns were placed in five stores in Kenya and about half a year later four of the most promising models were also placed in 5 stores (200 in total) in Niger. Local NGOs managed the projects (EAA in Kenya and ERE in Niger) [8] by keeping contacts with store owners and households. Although ESMAP purchased the lanterns in Belgium, India, Kenya, UK, and USA for between $40 and $120, manufacturers claimed that long-term retail prices would be of the order of $30-60 when sold in large quantities. At the moment however, if these lanterns would be available on the market, taxes, duties, and high margins (because of low sales volume) would double or even triple their price.

Cost is a major decisive factor. Rural households are conservative but would like to spend money on improving their living conditions, and lighting ranks high among the options. To what extent rural households are willing to spend money for this and what economic benefits would accrue to them is very difficult to measure through surveys. Relying on market indicators is much more appropriate way to determine this: What people are willing to pay for is what they want. The demonstrated willingness to pay in the lantern marketing tests is fairly high, but there is a limit as solar lanterns cannot be more expensive than solar home systems that provide additional benefits. The ESMAP activity showed that households perceive benefits from improved lighting to include

(1) better education for children (doing homework at night),

(2) extension of effective day for women, and

(3) better socializing and more productive meetings for men, indicating a positive link between the use of solar lighting and development.

If given a choice, people will choose the option that best suits their needs, keeping a close eye to the cost-benefit ratio. The ESMAP surveys showed that the perceived ideal solar lantern: is durable, has a high luminous flux that is fairly evenly distributed, gives a good quality spectrum light, is able to operate more than three hours per night (every night), and has spare parts readily available. The light output desired is high: the 200–300 lumen from a 5 watt compact fluorescent (CFL) or a 6 watt tubular fluorescent lamp (TL) are acceptable whereas the 160 - 200 lumen from a 4 watt TL [9] are not; a lantern with a 6 watt TL and a modified ballast to reduce electricity consumption (it only consumes 3 watt) was not appreciated because it compromised the light output and quality. The main reason for 56% of the households in Kenya and Niger who purchased a solar lantern was to modernize or to have better lighting at home (see Figure 1). In Niger, about 25% indicated that they would use it in a shop or workshop, for commercial or productive purposes, and 31% said they would use it for their children to study. In Kenya, 28% said they would use it to save some money on drycell batteries and kerosene, and 15% wanted to use it also for a radio connection. The lanterns were used in several locations within and around the house and were carried to the spot where they were needed most. Not a single household reported that it used the lantern in a single room only. Some 52% could not even indicate in which room it was used most while 23% said it was the living room and 17% said it was the bed room. Beneficiaries included children (17% of responses), women (39%) and men (39%), and 5% was for other purposes (use while traveling, to give away as a present, status, etc.). Solar lanterns thus provide a direct link to increased living standards, and indirectly to rural development.

Expenditures for kerosene and drycell batteries became significantly lower after people purchased their lantern: Kerosene expenditures in Kenya were reduced by over 60% (59 % of interviewed households responded), and drycell expenditures by as much as 90% (but only 11% of interviewed households responded – those who had purchase a lantern model with a 12 V battery or Nickel-Cadmium batteries). Mean monetary savings on a yearly basis amount to $41 for kerosene and $46 for drycell batteries in Kenya, and $46 in Niger for both combined. This suggests a minimum payback time of about 1–1.5 years, indicating that solar lanterns may also generate direct economic benefits.

The first step up the energy ladder is a crucial one as it provides the largest incremental benefits. Stepping up from candles or a small kerosene wick lamp to a 6 watt TL-type fluorescent lamp represents literally the difference between day and night. Although people sought increased lighting levels, once they actually enjoyed these, they quickly adopted them as their new standard and desired still greater illuminance. People had a choice, as several different models were available at any one time, and there was no pressure to buy any lantern at all. People had no problem with the fact that something new had now become available, and they showed clear preference for one or two models and quickly purchased a model for cash. The two preferred models were sold out in less than three weeks in both countries and they were not necessarily the cheapest ones available, although people suggested reducing the price so that even more people would be able to afford them. It is remarkable that there are so few differences in responses from Niger and Kenya [10], which suggests that the results might be valid for other parts of Africa as well. Three models were rejected (on the basis that not a single lantern was sold), and the jury is out on three other models (a few sold). This outcome certainly reveals clear and consistent market preferences.

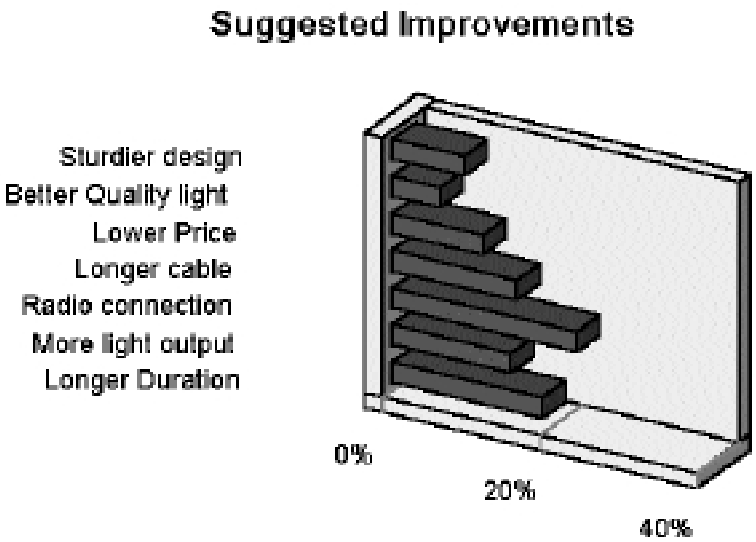
Most solar lanterns were unacceptable from a strictly technical point of view. They lacked low-voltage disconnects, and had poor quality light bulbs or electronic ballasts; even if low-voltage disconnects were present, they were set to disconnect at below 50% state of charge (SOC), thus not really protecting the battery. Many lamps showed blackening in an early stage. Households returned about 18% of the lanterns that they bought. The main reason quoted for returning was technical failure, resulting in unsatisfactory performance. In general people were satisfied with the increased services rendered by the lanterns, as dissatisfaction *per-se* was not given as a reason for returning a lantern.

DISCUSSION

Even though the solar lantern designs are not yet technically reliable enough, it appears that they will be fully paid back from energy savings. The absence of low-voltage disconnects is likely to result in early failure of batteries, and poor quality ballasts will reduce the lifetime of fluorescent tubes. The lanterns will be used daily, often in a hot and humid environment, and carried around the household all the time, putting stress on the physical strength of the housing and its components. But, most of this can be overcome if replacement parts are available. Therefore, it makes sense to promote solar lanterns, albeit with technical modifications, to provide rural households with a decent low-cost option to obtain minimal modern lighting services.

The fact that lanterns were available right in their own village was greatly appreciated. Although solar modules are readily available in all cities and most large to medium towns in Kenya (in Niger in the capital only), solar lanterns are not available outside the capital. If solar equipment suppliers want to increase their business, they clearly need to build a better rural delivery mechanism for solar equipment and spare parts, and not limit themselves to large towns or the capital.

Transport costs will render lanterns some 10% more expensive to the end user, import duties and VAT will bring it up by another 20-30%, and margins by another 30-40%. This brings it beyond reach for many potential cus-



tomers. Reducing or eliminating duties and taxes will help in generating higher sales, further reducing the need for high margins. The economic rationale, in addition to a social rational, for removing duties and taxes is:

(1) total tax revenues are likely to be small (assuming a market of 50,000 kits per year at $65 CIF per lantern, and a 30% combined duty & VAT regime, the treasury will not even gain $1 million);

(2) subsidies flowing to rural electrification programs are likely higher than potential tax revenue from solar lanterns;

(3) solar lanterns are likely to be benefitting more rural people than rural electrification programs;

(4) it appears to be difficult to bring modern lighting services to rural households for lower costs than with solar lanterns; and

(5) in fact, many countries have abolished duties and taxes on conventional electricity generating equipment but levy these on solar equipment "because these are luxury items". There should be a level playing field between the different alternatives, and solar energy is definitely one of the alternatives.

SUGGESTED MODIFICATIONS

The survey data suggests the following: About 23% of the total responses (multiple responses were allowed; see Figure 2) indicate that people also want to power their radio from their solar kit, and 40% want to have more hours of light, more lumens, and/or better quality light. One of the ways to do this is to add a second module to the solar lantern and by modifying the housing to add a socket for a radio connector. Since the batteries of most solar lanterns included in the tests are over-designed, this is technically possible. Such additional module could be purchased some time after the lantern is purchased (e.g. after the next harvest), or a larger module than normal could be made optional when people purchase their lantern. In other words, it is suggested to make solar lanterns as modular as possible so that people have a choice to buy exactly what they want and can afford.

Additional comments from the surveys were that some 16% of the households want a longer cable between the lantern and the module, a sturdier design (9%), better insect resistance, or lower-cost (11%). These are aspects that can and should be treated by manufacturers. The fact that all people who purchased the lantern with a 12 Volt battery had purchased it to use the battery for other purposes suggests that there also is a market for small batteries.

The better the user understands the functioning of the lantern, the longer its expected life. If (s)he understands that the battery's electricity storage capacity is limited, and that only a limited amount is stored during the day (and less on cloudy days, more on sunny days), and that energy consumption ideally should not exceed the energy stored during that day, (s)he is well on the way to use her/his lantern for a long time. As it is now, people have no way of telling how much energy was stored, nor how much they have already used. Simple feedback indicators could help improve users' understanding, thereby the likelihood of extending the life of the lantern.

THE WAY FORWARD

Prospective solar equipment users should carefully weigh their needs to their costs: A small solar module (say 12 Watt) and a good small battery (say 20 Ah) plus a few energy efficient appliances (lamps, radio) give more flexibility and benefits than a solar lantern, but also cost more. A solar lantern can be a good starting point for immediately increasing lighting services in rural areas, and benefits can be built up over a few years if this lantern kit is expandable. However, the time will come that the demand for more benefits outgrows the lantern kit's capacity to deliver. Nevertheless, the lantern is likely to pay back for itself

Table 1. Indicated Problems of PV Systems

Module size	functions well	too limited power	battery dead	poor performance of appliances	other	Row Total
			Indicated Problems with System			
1 - 15 watt	104	31	34	16	8	193
16 - 25 watt	42	10	10	6	4	72
26 - 45 watt	53	7	23	8	7	98
46 - 200 watt	30	4	9	3	-	46
total in sample	229	52	76	33	19	409
row percentage	56%	13%	19%	8%	5%	

Source: 410 Household PV System survey, ESMAP/EAA, 1997

over time, so the investment is worth considering. More different models, preferable of better quality and of lower costs, should be actively marketed in rural areas.

SOLAR HOME SYSTEMS

ESMAP also carried out a survey with a random sample of 410 actual users of solar electric systems in Kenya, and collected information on the development of solar electricity over time, the actual state of the equipment, and users' long-term view on solar electricity [11]. This gives a good insight how the market for PV systems operates when it is demand-driven.

If people build up their electric system in small increments and over several years, they can have their cake and eat it too: In such a way, they can afford to pay the equipment costs and satisfy their immediate needs. This is how people design their systems, hardly anyone buys a complete kit but most people will buy several components over time. However, they often cannot buy what they prefer: It is simply not available in their own neighborhood (such as rural areas), or the type of equipment carried by PV retailers/distributors is often not much of their interest (they do not want or cannot afford complete kits or large sized and expensive components). Entry level equipment, such as a solar lantern, is usually hard to find, even in capital cities. Distributors/retailers perceive the rural market to be small and not worthy of developing; They rather concentrate on large modules (40 watt and up) or complete system kits. One cannot blame them, as many donor-financed projects precisely promote that type of equipment and place relatively large orders from time to time. Because retailers do not deliver what people want, low-cost, often low-quality equipment is starting to be manufactured locally, in particular light fixtures and ballasts for fluorescent lamps. The survey in Kenya showed that for every imported fluorescent lamp fixture at least an equal number of locally manufactured fixtures is used.

People often already use a car battery and a small black and white TV, plus many lamps before they even think about buying a solar module. Since amorphous or thin film modules were introduced in the country, people started buying these more and more, to the point that they now have taken over from poly or mono crystalline modules. Amorphous modules are low-wattage, and fairly cheap; They therefore correspond well to people's expenditure patterns. The survey showed evidence that such modules of one specific brand tended to fail too soon, whereas other brands generally seem to perform well. The mean size of the module over the 410 household sample was 26 watt (median: 20 watt; mode: 12 watt). On average over the whole sample as many as nine lamps were connected to a solar system (see Table 2). About half of the lamps were incandescents, one quarter were imported tubular fluorescents, and the remainder fluorescents using locally manufactured luminaires. When asked what households would do if connecting them to the electricity grid in the near future would not be a realistic option, 70% of the sample said they would invest in improving their solar system, and 28% said they would also buy more 12 Volt lamps and 14% said they would start buying other 12 Volt appliances.

Of the people that are using a solar system in Kenya, 44% of the sample had purchased it to power several appliances: a TV, radio, and lights; 28% to power lights only; and 24% to power their TV only. Also, even though 60% said that they were satisfied with their system, 37% were not satisfied, and 3% were uncertain, 94% would recommend a solar electric system to a friend, 4% possibly, and only 2% would not recommend it. This signifies that rural Kenyan households perceive solar electricity to be a real solution to their modern energy needs, irrespective of the state of functioning of their own solar electricity equipment. This is good news for solar equipment and appliance manufacturers.

Table 1 shows the problems users said they experienced with their solar electric systems. Over half (56%) say their system functions well. The fact that 19% have a problem with the battery and 13% would like to have more power suggests that systems are under-designed and over-used. Eight percent have a problem with lamps or appliances, displaying the poor quality of locally made, and cheap fluorescent luminaires that are available from small shops in towns. More than half of all users say that they have replaced parts of their system, with batteries the most, followed by lights.

Only 10% of the sample have a charge controller, of which 18% were by-passed. From an engineer's perspective, leaving out a charge controller on a PV system is a serious error. However, from the cash-constrained point of view of a consumer, the decision not to use a controller is justified. First, the charge controller costs close to $100

Table 2. Average Number of Lamps and Other Appliances Used

	Size of PV System				
	1–15W	16–25W	26–45W	+ 46W	total
Incandescent	3.1	4.1	5.2	5.8	4.2
Fluorescent	2.4	1.7	3.4	3.8	2.9
Total lamps	3.4	4.7	6.6	7.2	5.0
% of households with a TV	87%	88%	94%	89%	89%
% of hh with Radio/Cassette	70%	69%	74%	61%	70%

Source: ESMAP/EAA, 1997

Table 3. Savings Reported (Kenyan Shilling, KSh, per month)

		Size of PV System			Row Total
KSh/month	1-15Wp	16-25Wp	26-45Wp	46-200Wp	
battery charging savings	94	80	96	78	90
kerosene savings	161	213	310	373	230
drycell savings	214	206	276	233	230
other savings	0	17	15	18	9
total in sample (KSh/month)	470	517	696	702	559

Note: 1US$ = 55 KSh; Source ESMAP/EAA, 1997

(largely due to import duty and VAT), or about the cost of a 12 watt module. Second, there is little need to protect systems below 20 watt against over-charging, as under-sized systems do not overcharge. Local charge controllers have very low deep-discharge settings (11.4 volt and below) so they do not offer significant protection in that regard. Finally, consumers do not see the benefits of charge controllers and thus tend to leave them out of their configurations.

Given that most systems are much under-dimensioned and lack charge and load controllers, this overall rate of performance is remarkable and indicates that people have learnt how to operate their system to a certain extent - they possibly learnt this the hard way after their first battery died due to mis-use. Most households claim they maintain their batteries, and over 30% say they keep distilled water at home. More than 90% of systems use ordinary car or lorry batteries, or “solar batteries” (car batteries with thicker-flat-plates). The most commonly used battery was a 100 Ah lead-acid car battery, although people favored the 75 Ah battery when it became available. Batteries are made locally, and come now with a one year warranty. The cost of a 75 Ah car battery is US$ 75 and up. As with modules, a smaller battery better fits households’ expenditure patterns, and should be developed. A small panel will not be able to fully charge a large-sized battery, unless the load is not switched on for several days in a row, which is an unlikely occurrence. The battery is likely to be operated in such a way that it fluctuates around the completely discharged state, only storing the energy of one day’s worth of sunshine. This is not a practice that yields long battery life, for which it would be much better if the battery were full every day.

Table 2 shows the mean number of lamps connected to a solar home system in Kenya. The smallest systems (with a 12 watt module) have on average 3 lamps, and the largest systems (more than 45 watt) have 7 lamps. Roughly half of the lamps are incandescent, in the 1 to 10 watt range ($1-2), and are used in spaces where light is needed sparingly from time to time. Such lamps are only a fraction of the costs of fluorescent lamps and can provide useful service (cf. a toilet with and without a 1 Watt incandescent lamp). The TL type lamps are overwhelmingly used, if not just because they costs much less than CFL lamps. One or two CFL types can be found ($25-42), but the majority of lamps are TL-types. Of the fluorescent light fixtures used in the survey sample, about 50% were imported ($25-35) and 50% were locally made.The latter are only a crude attempt to produce fixtures, with hand-wound induction spools and a minimum of electronics. Early blackening is a major problem, but cheap fluorescent replacement bulbs can be found in many small rural shops. The emerging pattern is clear, people want to have a lamp in every room, but cost is a major concern.

Savings on kerosene, drycells, and battery charging as reported by households with a solar home system amount to about US$10 per month, as shown in Table 3. For rural areas, this is a considerable amount of money, and it seems to replace most energy expenditures (other than for cooking) people indicated before they had a solar electric system. Savings observed with solar electric systems are higher than savings with solar lanterns, consistent with the fact that the latter provide more services.

THE WAY FORWARD

The problem appears to be a chicken-and-egg situation: Potential rural clients are not supplied with solar electric equipment, although they are willing to invest in such equipment. More choice, and less expensive equipment would certainly help to increase sales. The question then is, how to make this happen and connect suppliers with potential clients. Based on the above, recommendations are made, to governments and to manufacturers, suppliers, and retailers of solar electric equipment. These recommendations should be pursued simultaneously for best results.

The enabling policy considerations that should be systematically addressed include removal of high import tariffs and excise taxes, to ensure that solar equipment is not unduly punished, including solar lanterns and components of solar home systems. There should be a level playing field between all possible options for providing modern energy services in rural areas. It serves no one to make access to solar electric equipment difficult as it may be the only modern energy service option for many rural people for several decades to come. In fact, the use of solar equipment should be nurtured, and its efficient and rapid commercial distribution should be facilitated and promoted. This will be a good start to bring the benefits of the 20th century into the homes of many rural people.

Manufacturers, wholesalers, retailers should better listen to the suggestions made by rural people, and try to improve the supply of solar electric equipment accordingly. The potential market in developing countries is enormous, but only for the right type of equipment. A recent market study for Kenya [12)] shows that roughly 1.4 million lanterns and 0.9 million small solar home systems are the targets for cash sales, still leaving about 40% of the rural population or 1.6 million households without any electricity supply at all. Although the exact numbers are not very important as they will vary considerably from country to country, it is important to note that the potential market is very large indeed.

As the demand for solar equipment will largely come from rural areas, the infrastructure or delivery mechanism needs to be created there, not only for sales of equipment, also for installation, repairs, and sale of spare parts. Rural people are prone to purchase more quickly if they can buy in their own neighborhood. A more modular approach to equipment with options such as larger modules, modules in parallel, lanterns with one or two lamps, or a detachable lamp, a radio socket, a plug to charge from the mains (for peri-urban areas), etc., will also make solar equipment more accessible to rural households. Low-cost designs are likely to be sold more quickly, and it is up to manufacturers to make sure this is addressed in the redesigning of their models. The lighting market in developing countries is a new market, distinctly different from the weekend or the luxury market in western countries. The sheer size of it warrants a good and fresh look at packaging new equipment. Low-cost luminaires, using high efficiency lamps and other innovative lighting technologies (such as Light Emitting Diodes, or LED), should be developed and promoted in rural areas.

To better operate their solar electric equipment, users need to get feedback on the battery's level of (dis)charge in one way or another. An indicator light for proper battery operation would be useful, showing for example that the battery is running low or that the consumption for that day exceeds the amount of energy accumulated that day. An audible alarm, or a short period of flashing light to warn users of impending power cut-off would be useful as well.

CONCLUSION

For normal market development, choices should be available to end-users. Lighting choices in developing countries are particularly poor:

(1) Solar lanterns are generally not available;

(2) Lamps are usually promoted as part of a complete kit, but even then the choice is the retailer/distributor's and not the end-user's;

(3) Mostly imported luminaires with tubular fluorescent lamps are available, more efficient compact fluorescent lamps can hardly be found. Locally manufactured fixtures (using imported lamps) are becoming available, but are technically very poor; and

(4) equipment is not available there where it is needed most, in rural areas.

Unless the solar electric industries seriously start looking at rural areas as a real marketplace – albeit one where consumers demand low-cost equipment – rural households will remain in the dark and will enter the modern 20th century long after its end. There simply are not enough donor or government financed projects around to provide modern solar electricity/lighting services to all rural people within the next 20 years or so. Providing those services through grid-based technology is even less likely to take place. Developing the solar electric market will greatly accelerate the access rate for rural households to modern energy services, but this will largely depend on availability of appropriate equipment, at convenient rural outlets, and at reasonable prices.

As far as we know and understand it, rural households are ready to do their part of the business, if only you could do what you normally do best: Satisfying a demand in a market that seems to be enormous. ●

ENDNOTES

1) This article reflects the views and opinions of the author and does not in any way reflect the views of the World Bank Group.

2) Rural Energy and Development - Improving Energy Supplies for 2 Billion People, the World Bank, 1996

3) A Comparison of Lamps for Domestic Use in Developing Countries, World Bank *Industry and Energy Department Working Paper No 6*, June 1988

4) The Joint UNDP/World Bank Energy Sector Management Assistance Programme (ESMAP) is a special global technical assistance program run by the World Bank's Industry and Energy Department. ESMAP provides advice to governments on sustainable energy development. Established with the support of UNDP and 15 bilateral official donors in 1983, it focuses on policy and institutional reforms designed to promote increased private investment in energy and supply and end-use energy efficiency; natural gas development; and renewable, rural, and household energy.

5) ESMAP survey data carried out under different projects in Africa and Latin America.

6) Solar module, solar battery, charge & load controller, a fixed number of fluorescent lamps, cables and switches.

7) Solar Energy Solutions for Rural Africa, *Power*

Engineering International, March / April 1996.

8) Many thanks go to Mark Hankins and Daniel Kithokoi of Energy Alternatives for Africa, and Kiri Tounao and Saley Yahaya of Energies Renouvellables et Environnement.

9) Although TL, PL are universally used, these are Philips' system to indicate the type of lamp: TL stands for the traditional tubular fluorescent lamp, whereas the PL stands for the more modern version of a compact fluorescent lamp.

10) Kenya and Niger are quite different from many different points of view: cultural, economic, natural resources, per capita GDP, infrastructure, etc.

11) "Solar Electricity in Africa: A Reality", *Energy Policy* (forthcoming)

12) Kenya Photo-Voltaic Rural Energy Project (KEN-PREP), Results of the 1997 Market Survey, K-REP, EAA, Resource Analysis. Final Report, June 1997

Workshop 2

Computer Tools for Lighting Performance Assessment