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15 YEARS OF DEVELOPMENT IN ACCESS TO OFF-GRID RENEWABLE ELECTRICITY: insights from the Ashden Awards

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379 organisations providing access to renewable electricity, who applied for Ashden Awards during the past 15 years, mostly used solar home systems and solar lamps. Trends found are that the number of applicants and the scale of their work have increased; East Africa has overtaken South Asia as the region with most applicants; and most applicants are now for-profit enterprises. Case studies of Ashden winners illustrate benefits and challenges.

Off Grid Electric's Agent Success Coordinator Jessica Paul showing the components of the Off Grid solar home system
Source: Ashden/Anne Wheldon

Ashden is a charity that promotes the use of sustainable energy at a local level. This paper was researched and written by members of Ashden's international team. Lead author Anne Wheldon (MA, PhD, FEI) supports assessment of applicants, research and writing; Chhavi Sharma (BA, MSc) runs the international awards and post-awards support programme; Ellen Dobbs (BA, MSc) leads on research and monitoring of Award winners.

KEYWORDS

- ELECTRICITY ACCESS
- MINI-GRID
- HYDRO POWER
- SOLAR HOME SYSTEMS
- SOLAR LAMP
- MOBILE MONEY
- PAY-AS-YOU-GO SOLAR

INTRODUCTION

Ashden is a UK charity that promotes the use of sustainable energy at a local level, because of its human and environmental benefits. A core part of Ashden's work is to highlight successful sustainable energy practitioners through the annual Ashden Awards, and support them to take their work further. Ashden's largest Award programme focuses on developing countries, in particular on the provision of energy access. This international programme has received about 1,400 applications and made over 90 awards during the 15 years since the Awards were launched.

This paper reviews internal information held by Ashden on the 379 applicants (and 41 winners) working on sustainable electricity access, to identify trends in access to sustainable electricity in the work of applicants and winners, and provide insight into the wider sustainable electricity access sector.

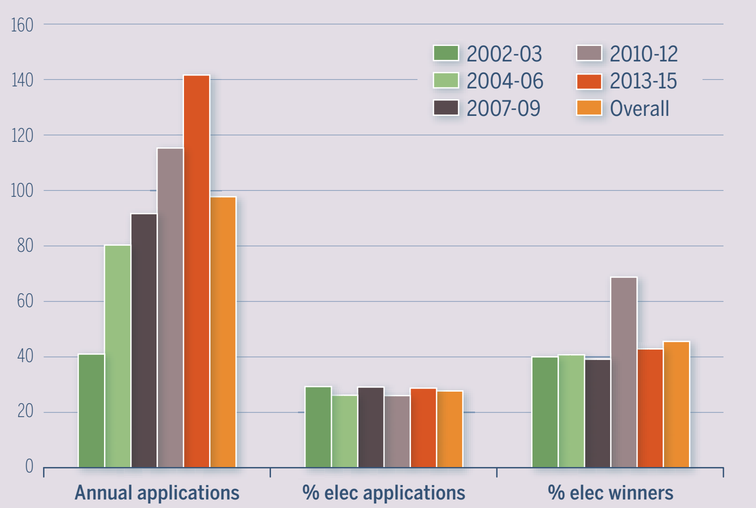
1. ANALYTICAL FRAMEWORK

1.1. SELECTION CRITERIA

Ashden Awards are for organisations that can show existing achievement in providing sustainable energy at a local level, along with innovation and potential for growth and replication. All winners must be delivering significant social, economic and environmental benefits. They must be on a path to achieving financial sustainability, and have the capacity and commitment to take their work further. Winners in specific Award categories (for example "Clean energy for women and girls", "Innovative finance for sustainable energy" and "Increasing energy access") must meet additional category-specific criteria. The application process has changed somewhat over the years, but broadly follows the following steps.

- Applicants put themselves forward for an Award by filling in a standard form. Any organisation may apply. A "longlist" of around 20 is selected from these initial applications. All longlisted applicants are sent more detailed questions tailored to their specific work, and must also provide financial information and references. Specialist assessors review all materials submitted, and an expert judging panel selects about ten finalists from the longlist.
- An essential part of the application process is to see the work of finalists on the ground. All finalists are therefore visited by an Ashden assessor who meets the people involved in the organisation, reviews the work in action, interviews people who are benefitting from it, and obtains answers to questions from the judging panel. Assessors report back to the judging panel who select winners in each Award category. The Ashden team prepares a detailed case study on each winner which is made available on the website (www.ashden.org/winners) along with a short video and photos of the Award-winning work.

Average annual applications for Ashden International Awards, and percentage of applicants and winners providing access to sustainable electricity



Source: Ashden

Figure 1

- Winning an Ashden Award brings a cash prize and publicity. Ashden also provides a tailored support package to each Award winner, and follows their post-Award progress.

1.2. DATA

The application and assessment process generates detailed information on the work of individual applicants (both quantitative and qualitative). This collated information forms the evidence base for this paper.

1.2.1. Sample size

Ashden Award applications were initially screened to select those that provided access to sustainable electricity, and whether the applicant became a winner. Applications were analysed in three-year groups, to smooth the year-to-year variations inevitable with small numbers (although the earliest group contained just 2002 and 2003 applications, because those for 2001 could not be located).

Figure 1 shows that the number of applications for Ashden Awards has increased substantially over time, from about 40 per year in 2002-03 to 140 per year in 2013-15. Despite this significant increase in numbers, the proportion of applicants providing access to electricity from renewable energy stayed the same, at around 28% (overall 379 out of 1,369 applications). Most other applicants provided cleaner and more efficient cooking, also heating and water supply. Applicants providing access to electricity were generally judged to be stronger than others, and produced about 46% of final winners (41 out of 90).

The 379 applicants and 41 winners providing access to electricity from renewable sources form the sample on which the quantitative analysis in this paper is based. The data used is that provided to Ashden at the time of application, because this provides a common reference point for all applicants.

"THE NUMBER OF APPLICATIONS FOR ASHDEN AWARDS HAS INCREASED SUBSTANTIALLY OVER TIME, FROM ABOUT 40 PER YEAR IN 2002-03 TO 140 PER YEAR IN 2013-15."

1.2.2. Possible biases of the sample

The Ashden application process is designed to highlight achievement, rather than as a tool to overview the energy access sector. One possible bias in relating the findings of this paper to the wider sector is that Ashden is less well-known outside the Anglophone world (although all materials for making an application are translated into other widely-used international languages, including French, Spanish and Chinese). Another is that businesses and not-for-profit organisations might anticipate more benefit from winning an award than public sector bodies would do, thus making public sector bodies less likely to apply. As we make clear throughout this paper, Ashden rewards achievements specifically in *sustainable* energy, so organisations increasing energy access through the use of fossil fuels would not be eligible for an Award.

2. QUANTITATIVE ANALYSIS

2.1. WHERE DOES THE WORK ON ACCESS TO SUSTAINABLE ELECTRICITY TAKE PLACE?

The 379 applications were coded into the broad geographical categories: South Asia, Rest of Asia, East Africa, Rest of Africa and South and Central America. A few applicants were coded as 'global' if their work spanned several geographical regions.

Figure 2 shows that most applicants providing access to electricity worked in South Asia (32%), East Africa (21%) or elsewhere in Africa (17%) – the regions that are home to about 90% of the people who currently lack access to electricity (World Bank, WDI, 2012). Some of this geographical spread may relate to Ashden being less well-known outside the Anglophone world, as noted above.

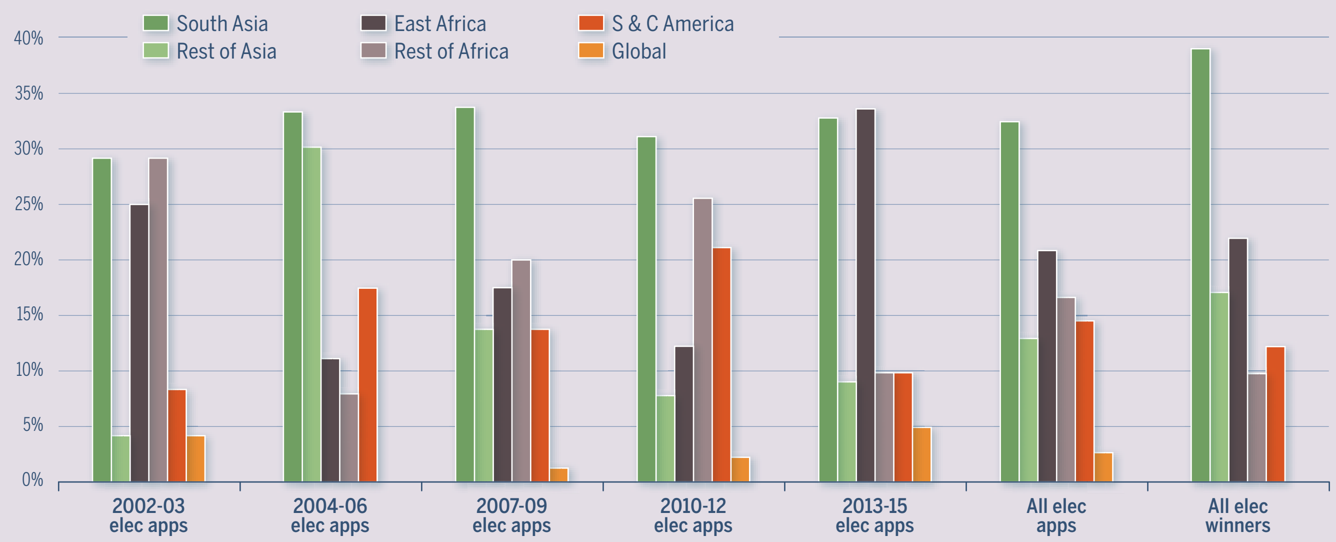
South Asia had the largest share of applicants until 2013-15, when it was overtaken by East Africa. In terms of winners providing access to electricity, South Asia has the largest share followed by East Africa. One reason for the growing importance of East Africa in recent years is the widespread use of mobile money, which has enabled new ways of paying for electricity: this will be discussed further in the case study of Off Grid Electric.

2.2. WHAT TECHNOLOGIES ARE USED?

An initial review of the 379 applications identified three broad categories of technology used by Ashden applicants to provide sustainable electricity access: renewable-powered mini-grids, individual home systems (nearly all solar powered), and solar-powered lamps. The latter are mainly lamps supplied with an individual PV module, but in a few cases are lamps or batteries charged at a central point like a shop or kiosk with PV modules.

Figure 3 shows solar home systems are the main technology used by both applicants (42%) and winners (51%). However, solar lamps have increased in popularity, and have been the dominant technology since 2010. Renewable-powered mini-grids maintain a fairly constant representation among applicants, averaging 27%, and account for a similar proportion of winners (29%).

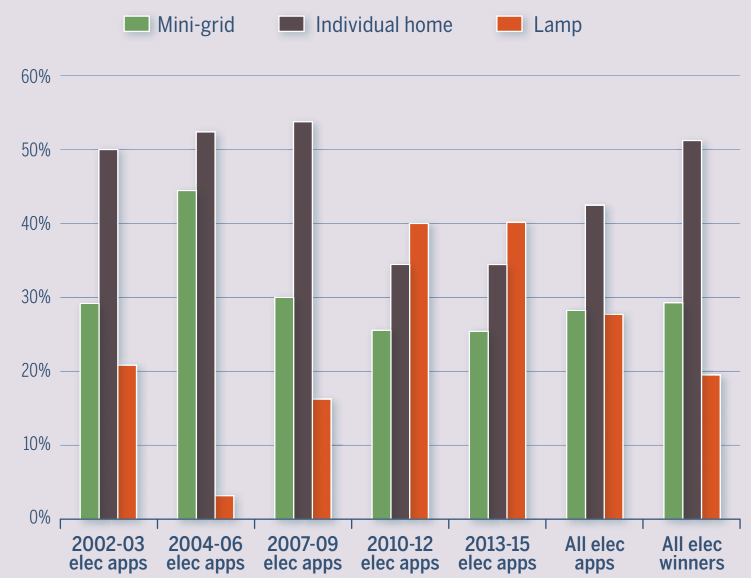
Location of work on access to sustainable electricity: applicants and winners



Source: Ashden

Figure 2

Technologies used to provide access to sustainable electricity



Source: Ashden

Figure 3

"SOUTH ASIA HAD THE LARGEST SHARE OF APPLICANTS UNTIL 2013-15, WHEN IT WAS OVERTAKEN BY EAST AFRICA."

Developments in these technologies and their use, that Ashden has observed, are summarised below.

2.2.1. Renewable powered mini-grids

Renewable-powered mini-grids can provide electricity access to a group of homes, public buildings and small businesses. A thousand or more customers can be connected if the power is sufficient, but all need to be quite close to the power source (typically within a few kilometres), otherwise the cost of cable to connect them becomes prohibitive.

Obviously the choice of renewable source depends on location. Small hydroelectric schemes work well in areas with high rainfall, for example providing power to remote mountain villages in Indonesia (IBEKA, 2012). A wide range of biomass can be used for power generation: gasifying waste biomass and using the gas to run an engine and generator is one example (HPS, 2011). Wind turbines are also a possibility. Solar photovoltaics (PV) have decreased rapidly in price over recent years and their low maintenance requirements make them particularly attractive for remote areas, like in rural Kenya (SteamaCo, 2015). PV mini-grids require rechargeable batteries for storage because power is supplied only during daytime, which is often not the time when electricity is used. Among Ashden applicants, hydro (61%) and PV (26%) are the main renewable power sources for mini-grids, with PV becoming more important in recent years.

Mini-grids require complex planning, construction and long-term management. A particular management challenge is finding an acceptable way to share out and pay for the electricity. Fifteen years ago, many systems were under community management, and electricity sharing was fairly informal, often with only token payments (for example: AKRSP, 2004). Increasingly, to keep systems performing well, paid operators are used for day-to-day management. Electricity payments are set at a level to cover salaries and maintenance, and, for fairness, are increasingly based on metered electricity consumption (for example in Afghanistan: GIZ-INTEGRATION, 2012). In East Africa, the use of mobile phones and mobile money is widespread, and mobile money payment is starting to be used for mini-grid electricity (SteamaCo, 2015). This cuts the cost of collecting payments.

2.2.2. Individual home systems

In many places, electricity access can be brought more quickly by providing renewable power systems to individual buildings, rather than using mini-grids. Individual systems also avoid complex long-term management, and can serve buildings in areas that would be too remote for mini-grid connection.

In Ashden's experience, individual systems are nearly always powered by PV ("solar home systems"), although in a few cases individual wind turbines or very small hydroelectric generators have been used. Solar home systems use a PV panel to provide power for two or more lights and, increasingly, for phone charging too. Depending on size they can also power other small appliances like radios, fans, TVs and laptops. All require rechargeable batteries for storage.

In 2007, a basic solar home system like those sold by SELCO (2007 winner) used around 35 Wp of PV, a lead-acid battery and an electronic controller to supply four ~200 lumen fluorescent lights. It had to be installed by a trained electrician, and cost around USD 400 (USD 460 in 2015 money).

Much has changed since then. PV prices have fallen dramatically. A recent analysis by the Fraunhofer ISE (Fraunhofer, 2015) showed that during the 14 years from 2000 to 2014, PV module prices on the world market fell by about 90% from EUR 5 to 0.5 per Wp (and that followed a fall of 80% during the preceding 16 years). LED lights are now more efficient and long-lasting than fluorescents, and available in a wide range of output and configuration. Long-life lithium-ion batteries are now widely used, particularly in very small systems. Electronic controls have improved enormously.

Taking advantage of these developments, several businesses now sell solar home systems as Pay-as-you-go (PAYG) kits for DIY installation. System prices are significantly lower (although not to the same extent as PV modules, because other contributors to cost like batteries, lights, cables, manufacture and distribution have not changed as much). For example, the current entry-level kit from 2012 winner Barefoot Power (including a 6 Wp PV panel, four 75 lumen LED lights, battery, controller, two USB charging points, cables and connectors) retails for only about one-third of the price of the 2007 system above.

Such price decreases mean that more households can now afford a solar home system, but having to pay all the cost upfront is still a barrier. Pay-as-you-go (PAYG) using mobile money, described in the case study of Off Grid Electric, significantly reduces the upfront payment required from the customer and can make solar home systems affordable to many more.

2.2.3. Solar lamps

A modern solar lamp has a single high-efficiency LED light and a rechargeable battery, usually lithium-ion technology, in a case which is small enough to carry around. Solar lamps are designed to replace kerosene lamps or candles and provide better quality, and (on a lifecycle basis) cheaper light. They can also replace battery-powered LED lamps that are becoming increasingly popular in a number of African countries (Bensch et al., 2015), avoiding the need for frequent replacement of dry-cell batteries.

The recent developments that have changed solar-home-systems have also led to a growing number of solar lamps on the market, which are usually packaged and sold as “fast moving consumer goods”. The “Lighting Global” initiative of the IFC has had a major impact on the sector, bringing in quality standards and accepted methods to measure performance (Lighting Global, 2015). In parallel there are growing numbers of cheaper, uncertified solar lamps of varying quality.

Ten years ago, most solar lamps that Ashden encountered used fluorescent bulbs. The cheapest (for example: NEST, 2005 winner) cost around USD 35 (USD 42 in 2015 money) and needed 3 Wp of PV. Businesses like d.light (2010 winner) now sell solar lamps that meet Lighting Global standards, with prices that start at around USD 5. Such lamps provide modest light levels, around 20 lumens, but can be afforded by many more households than in the past (although they are not as cheap as some battery-powered LEDs). The cheapest modern solar lamps have integrated PV panels, and thus the disadvantage that the whole unit has to be left out in the sun to charge up.

In Ashden’s experience, the distinction between a solar home system and a lamp has blurred over time. Solar home systems have become smaller and cheaper, while top end lamps with detachable solar panels (costing around USD 42) now provide 150 lumens of light, different brightness settings, and one or even two USB charging sockets. Phone charging is important for many low-income households in remote areas, since mobile phones increasingly bring not just communication but financial service and knowledge.

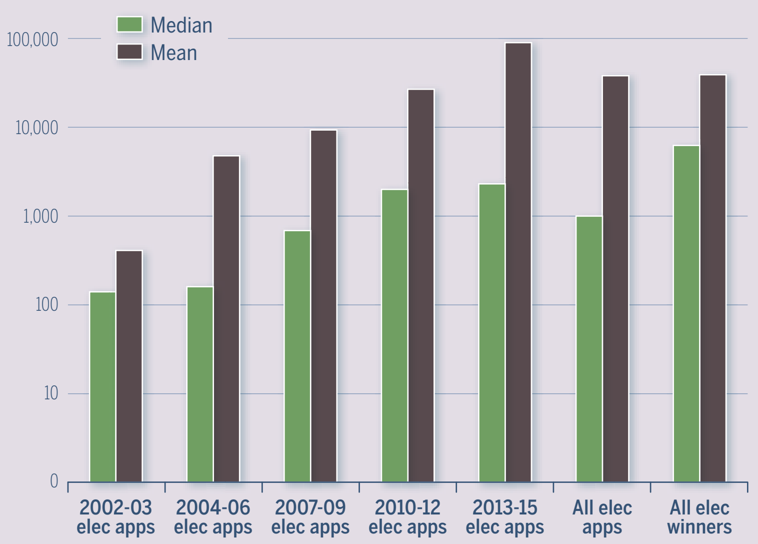
2.2.4. Tiers of access

The different technologies above obviously provide different levels of access to electricity. In order to track global progress in providing access, the Sustainable Energy for All initiative categorises access into broad “Tiers” (SE4ALL, 2015). A simple solar lamp is ranked at Tier 0, or at Tier 1 if it includes a charging socket. Solar home systems are typically ranked between Tier 1 and Tier 3, depending on size and functions. Tier 4 access, which provides enough power for tools and equipment for businesses as well as a wide range of domestic appliances, can be achieved with mini-grids.

2.3. SCALE OF OPERATION

We define “scale” of an application for an Ashden award as the number of households or equivalent that had been provided with access to electricity by the applicant, at the time of application. For mini-grids this is the number of households connected to a mini-grid, for individual home systems and lamps it is the number of systems sold or installed. In a few applications this information was not clear and estimates were made from the number of beneficiaries cited by the applicant.

Number of households supplied by Award applicants: mean and median values

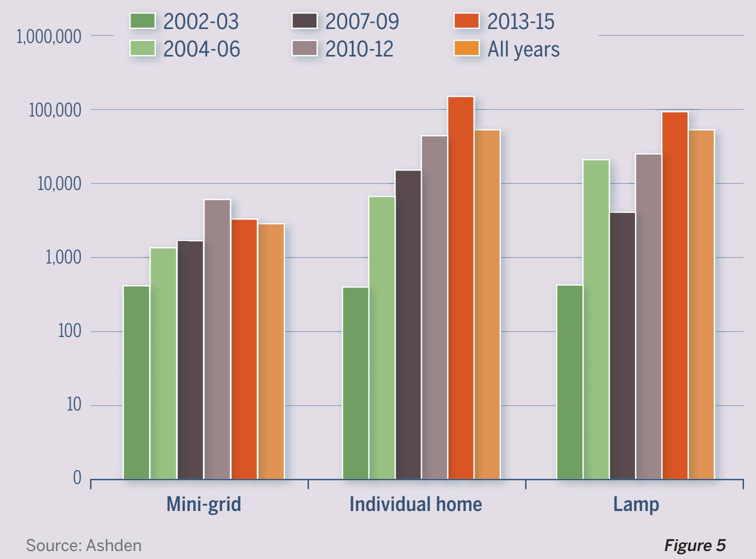


Source: Ashden

Figure 4

Applicants operate at widely differing scales, from tens up to millions of households. Given the relatively small number of applicants, it is difficult to choose the right averaging technique to indicate trends in scale. Figure 4 therefore shows two measures of the average number of households: the arithmetic mean and the median. It uses a logarithmic scale to cover the large range of scale. Both measures show that the scale of operation of applicants has increased substantially with time, from a mean of about 400 households in 2002-03 up to over 90,000 in 2013-15 (median from 140 up to 2,300).

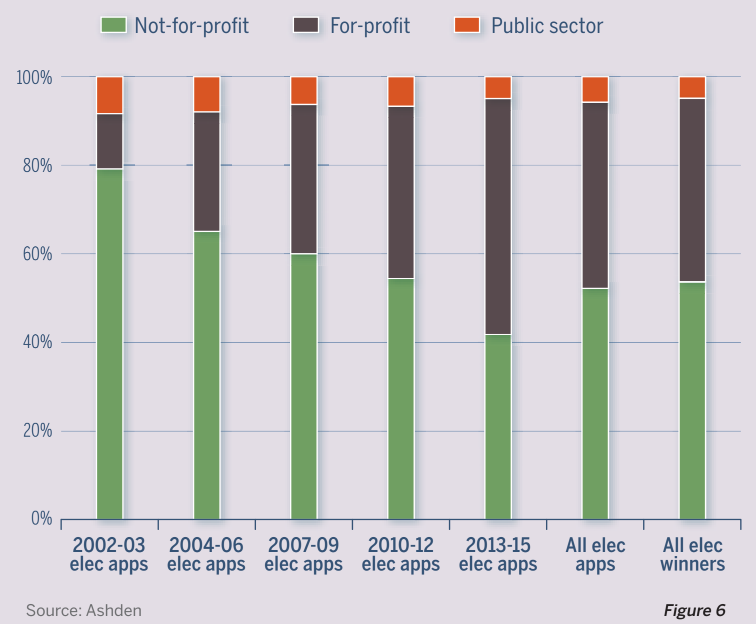
Number of households supplied by different technologies: mean values



Source: Ashden

Figure 5

Types of organisation applying for and winning Ashden Awards



Source: Ashden

Figure 6

In each time period the mean is higher than the median, showing that the data is skewed by a few very large numbers. This skewing has increased over time, which we think is caused partly by real change in the sector. Several renewable energy businesses and programmes have deliberately grown large, rather than focussed their work within a limited geographical area which was more normal 15 years ago, in our experience. However, the skewing also relates to our specific data set, which is applicants for achievement Awards. Some organisations defer making an application until their scale exceed that of previous winners, and thus over time have an ever-increasing bar to exceed.

Scale of operation varies with technology. Figure 5 shows that applicants reach many more households with solar home systems and solar lamps than with mini-grids. This is not surprising given that solar home systems and, in particular, lamps are small and easy to transport to individual homes. Mini-grids, by contrast, are complex projects. For each technology, the scale of operation has increased over time.

Note that the scale of *impact* of an organisation depends on the level of benefit to a household, as well as the scale of operation. Solar lamps providing Tier 0 or 1 access cannot provide the same benefits as Tier 4 access from mini-grids. This will be discussed more fully in the case studies below.

2.4. WHAT TYPES OF ORGANISATION APPLY FOR ASHDEN AWARDS?

Applicants were coded as for-profit; not-for-profit or public sector. A growing number of applicants identify themselves as "social enterprises", but because this term has different interpretations in different places they were all included in the "for-profit" category.

The profile of organisations applying for an Ashden Award has changed considerably over the past 15 years, as shown in Figure 6. In 2002-03, nearly 80% of the applications working on sustainable electricity access came from not-for-profits, but by 2013-15, the majority were for-profit organisations. Only a small number of applications come from public sector organisations: this may not reflect their importance in the sustainable electricity access sector as a whole, because – as noted earlier – such organisations might be less interested to win awards.

Several factors may have contributed to the shift from not-for-profit to for-profit applicants. One likely factor is experience from a number of government and not-for-profit programmes in the 1980s, which showed that "giveaways" tend not to lead to lasting uptake of new technologies. Another is the growing availability of private investment to the sector, both loans and equity. A third is that businesses can often change and adapt more quickly than not-for-profits, taking up new technologies and exploring new markets.

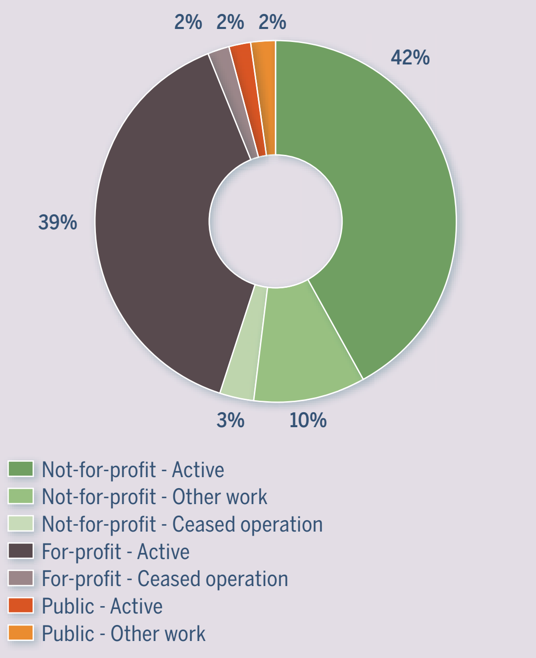
Here again, categories are somewhat blurred. Many for-profit businesses that provide access to electricity receive grant funding, at least in their early years. Equally, many not-for-profits are selling products or services in an increasingly "business-like" way. The case study of SolarAid below is an example of this.

2.5. CURRENT STATUS OF WINNERS

Ashden internal records and internet checks (November 2015) were used to identify whether winners remain active in the electricity access sector (Active); are active but now doing other work (Other work); or have ceased operation (Ceased operation). Figure 7 summarises the findings, and shows also the division into not-for-profit, for-profit and public sector categories.

Numbers are too small to draw strong conclusions from this, but it is clear that a large majority of the 41 winners (83%) are still active in the sector and very few have ceased operation (5%). Most of the 12% who have moved on to other work are not-for-profit organisations.

Current status of Award-winning electricity access organisations



Source: Ashden

Figure 7

3. CASE STUDIES AND IMPACTS

Three recent Award winners have been selected as case studies to highlight trends that were identified above. The studies also look in greater depth at other aspects of providing access to sustainable electricity, including the context and social impact of the work and the challenges faced.

3.1. SOLAR AID - SOLAR LAMPS

Although solar lamps can have significant impact in off-grid homes, it is still an enormous challenge to get lamps and backup services to the remote areas where they can bring the most benefit. UK-based not-for-profit SolarAid (2013 winner) took on this distribution challenge, using a "business-like" approach.

SolarAid set up a trading subsidiary, SunnyMoney, to develop a rural market for solar study lamps. SunnyMoney teams travel to different parts of a country and run sales campaigns through trusted head teachers who act as local agents. In this way, households in rural areas get access not just to the products but to backup services too.

Lamps are sourced from global suppliers, and have to meet Lighting Global standards. They are sold with warranties at prices between about USD 10 and USD 40, depending on size and features.

Several formal studies have been undertaken of the impact of solar lamps, and find different combinations of benefits. For example, a randomised-control-trial (RCT) in Bangladesh by Kudo et al. (2015) found decreased expenditure on kerosene and increased study time by children, in households with solar lamps. This study found no impact on school grades or on health. Grimm et al. (2015) conducted an RCT in Rwanda on the impact of PV lamps with chargers ("pico-kits"). They found that the lamps were intensively used and led to significant reductions in expenditure on kerosene, candles and dry-cell batteries, along with increased lighting hours in the day and more flexibility in how time was used. However, they found no impact on total study time, or time spent on domestic chores. A pilot study by Furukawa (2013) in Uganda found that children with solar lamps studied for longer but, somewhat surprisingly, achieved slightly lower school grades.

A SolarAid in-house study (Harrison, 2013) found that lamps were mainly used for study, also for cooking and general household lighting. Crucially, over 90% of households surveyed were satisfied or very satisfied with the lamps. The money saved on kerosene means that the cost of a basic lamp is recovered within three months. A large-scale RCT, initiated by Solar Aid, is currently in progress to determine the impacts of solar lamps on poverty alleviation.

Head teachers interviewed by the Ashden assessor said that they tried out the lamps in their own homes before becoming involved with the SunnyMoney campaign, to confirm the benefits. They

"IN 2002-03, NEARLY 80% OF THE APPLICATIONS WORKING ON SUSTAINABLE ELECTRICITY ACCESS CAME FROM NOT-FOR-PROFITS, BUT BY 2013-15, THE MAJORITY WERE FOR-PROFIT ORGANISATIONS."

Head teachers try out solar lights at a meeting with a SolarAid sales team
Source: Ashden/Anne Wheldon

highlighted the value of having lamps in school dormitories, as well as in homes, for both study and safety.

At the time of the Ashden assessment visit (March 2013) SolarAid had sold over 400,000 solar lamps in Tanzania, Kenya, Zambia and Malawi. By March 2016 this number had increased to 1.7 million. The SunnyMoney programme continues in Southern Africa, and recent pilot sales in Malawi have shown the potential for reaching lower-income households using PAYG technology in solar lamps (SolarAid, 2016a).

However, SolarAid's recent experience in Tanzania shows how quickly the sector can change. Tanzania was the country where SunnyMoney was most successful in building a market for solar lamps, and accounts for over 0.9 million of its sales. But during 2014-15, there was a rapid increase in competition from uncertified solar lamps (some of them fakes of popular certified models), also cheap lamps powered by dry-cell batteries, and SunnyMoney sales fell substantially. SolarAid decided to wind up operations in Tanzania, but the SunnyMoney Tanzania brand has been taken over by local enterprise ARTI energy (SolarAid, 2016b).

3.2. OFF GRID ELECTRIC - SOLAR HOME SYSTEMS

Off Grid Electric (2014 winner) is a for-profit business based in Arusha, Tanzania. Its founders wanted to make solar home systems a mass-market option. However, they recognised two major barriers to customers: the initial cost of buying a system, and low expectations of after-sales service.

The growing availability of mobile money in East Africa helped provide a solution to the first barrier. Off Grid Electric provides an agreed level of electricity service from a 5 or 10 Wp solar home system installed in a customer's home, with an entry-level service of two bright lights and a phone charger for eight hours per day, and the option to add further appliances at an additional cost. Customers pay a deposit of around USD 8 and then a daily fee of between USD 0.20 and USD 0.60. These PAYG fees are paid using mobile money, with a minimum payment of one day's use.

Incentivising local agents provided a solution to the second problem. A network of local agents is paid not just to find customers and install systems, but also to provide ongoing aftersales service.

The PAYG approach removes the upfront hurdle of what would have been a roughly USD 100 purchase cost and makes the service accessible to lower income households. Equity investment has enabled Off Grid Electric to grow rapidly. At the time of the Ashden visit (March 2014) systems were in use in about 10,000 homes. The programme has expanded rapidly and is currently (October 2015) reaching over 10,000 more customers every month.

Users of solar home systems have reported many benefits to Ashden assessors, including increased study time for children, increased ease and time-flexibility for household chores, greater safety at night, and savings on kerosene. Many also report how charging mobile phones at home is both cheaper and more convenient than going elsewhere. An impact survey has been made of the successful World Bank/GEF-financed credit scheme for solar home systems in Bangladesh, which has led to about 3 million installations. This survey found that having a solar home system increased the time that children study in the evenings, decreased kerosene consumption, and provided health benefits, in particular for women (Samad et al., 2013).

Off Grid Electric customers interviewed in their homes by the Ashden assessor identified many benefits, including increased safety at night from lights outside homes; more customers attracted to well-lit shops; and children spending more time on study in evenings. Phone charging at home was really appreciated, particularly by women who spent more time than men in the home. The money saved on kerosene covered the PAYG charges.

3.3. SARHAD RURAL SUPPORT PROGRAMME (SRSP) - MINI-GRIDS

It is a huge challenge to provide electricity to regions like North-West Pakistan: isolated, often cut off by snow or earthquakes and plagued by political instability. Private businesses will not take the risk of working in such a region.

Local not-for-profit SRSP (2015 winner) has worked for many years with local communities, and seen first-hand how lack of electricity held back development. It saw the potential for producing electricity from hydro-power, because there are plentiful rivers and streams in the

Washing machines are powered by SRSP's micro-hydro system in the Bumboret Valley, Pakistan. This greatly reduces the drudgery of housework for women.
Source: Ashden/Martin Wright

region, but knew from experience that for a hydro scheme to succeed, the local community must take the lead. So in 2004, SRSP started working with communities to develop village-scale micro-hydro power schemes with mini-grids. All SRSP installations use high-quality turbines, made in Pakistan (hence able to be maintained locally), and include metered connections to homes, businesses and community facilities.

By the time of the Ashden visit in March 2015, SRSP had installed 189 micro-hydro schemes with a total capacity of 15 MW, bringing power to about 40,000 homes. The impact on home comforts, economic opportunity, and wider community development, reported to the Ashden assessor has been substantial. Electric light makes homes more pleasant, study easier, and health care safer. Phones, TV and internet provide access to new skills and a window on the world, reducing isolation.

Teachers told the Ashden assessor that electric light improves both academic performance and attendance because children can complete their homework, and are no longer afraid to go to school!

Crucially, the level of power available from a hydro-based mini-grid means that domestic appliances like washing machines and irons can be used, cutting the drudgery of housework for women. The level of power also enables new income generation, through a wide range of activities. Many like fruit-drying, craft work and hotels bring in much needed income from outside the region.

4. DISCUSSION

Ashden's experience of the development of the sustainable electricity access sector over the past 15 years is positive, because – as detailed above – a growing number of organisations apply for awards, their work is at an increasing scale, and most winners stay active in the sector. Trends identified are the growth in use of solar lamps; the increasing importance of for-profit businesses; and the rise in the significance of East Africa. Applicants have adopted global technological developments to offer better and cheaper services. Lower cost PV, better quality LED lights and mobile money PAYG are reaching rural homes. Although the Ashden application process was not designed to survey the sustainable electricity access sector as a whole, the trends identified in this paper may apply more broadly.

But despite these encouraging trends, 1.3 billion people still lack access to electricity (IEA, 2016), and most of these are in the poorest and most remote parts of the world. There are substantial challenges in providing access to all.

In our experience, businesses have a growing role to play, although we know from research with Ashden winners (Haves, 2014) that they face challenges, including access to working capital and developing appropriate sales and marketing.

However businesses – including socially-focussed ones – need customers who can pay, and tend to gravitate to where people have money and are easy to reach. There is continuing role for government and philanthropic funding, to support work in places where businesses will not venture (like the region served by SRSP) and to provide the groundwork for business-like operation (like SolarAid's grant-funded distribution approach).

There is also a dilemma about where to focus effort in terms of level of access. Rightly, there is a global ambition to bring everyone to Tier 4 or higher, to reduce domestic burden and enable economic opportunity. But our experience, from talking to winners and others, is that mini-grids to achieve Tier 4 are hard work to develop and, in particular, to manage long term. It seems unlikely that their use can be expanded sufficiently reliably and rapidly to achieve the SE4ALL goal of universal access by 2030.

For Ashden it is crucially important that no-one gets left behind, without access to electric light. Inability to charge a mobile device is, increasingly, part of being "left behind". Ashden therefore sees a continuing role for solar home systems and lamps to rapidly expand access in the immediate future, alongside efforts on mini-grid and grid-connection to offer greater opportunities.

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