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Exploring hybrid models for universal access to basic solar energy services in informal settlements: Case studies from South Africa and Zimbabwe

Damian Conway[a,*], Blake Robinson[b], Patience Mudimu[c], Tawanda Chitekwe[c], Kweku Koranteng[d], Mark Swilling[d]

[a] iShack Project, Sustainability Institute, Lynedoch Eco Village, Lynedoch, Stellenbosch, South Africa
[b] Sustainability Institute, Lynedoch Eco Village, Lynedoch, Stellenbosch, South Africa
[c] Dialogue on Shelter Trust, 13 Harvey Brown Avenue, Milton Park, Harare, Zimbabwe
[d] Centre for Complex Systems in Transition, Stellenbosch University, 19 Jonkershoek Road, Stellenbosch, South Africa

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ABSTRACT

In order to achieve Sustainable Development Goal 7 (SDG 7), innovative approaches will be required to deliver affordable, reliable, sustainable and modern energy to Africa's poor. As a partial contributor to this goal, Solar Home Systems (SHSs) are an increasingly affordable and reliable option for low-income, informal settlement, urban households to initially access electricity (for at least lighting and media) in a manner that bypasses the legal, financial and practical barriers that often impede grid electrification. Other authors have argued for adaptive hybrid models for delivering and scaling access to SHS so that synergies between government- donor- or market-led approaches can be harnessed to achieve truly universal, and thus equitable, access. We look at two case studies of SHS delivery models that could, if combined, embody some of the envisaged benefits of the hybrid idea. The first case study is a social enterprise in South Africa that operates as a subsidised fee-for-service solar electricity utility. The emphasis is on efficient operating systems combined with local job creation, which together help to minimise running costs and thus maximise end-user affordability and produce wider local economic benefits. The second case study, in Zimbabwe, uses well-established social processes and women-led savings groups to build strong organisational capacity and accountability within the community. This establishes a robust social contract and a resilient mechanism for technical delivery and grass-roots information flow. The respective strengths and weakness of these two models appear to dovetail in a way that supports the case for a combination of the two approaches in a partnership with a shared core mission of advancing SDG 7 for underserved residents of informal settlements in Sub-Saharan Africa.

1. Introduction

In 2015, the United Nations General Assembly introduced the Sustainable Development Goals (SDGs) to focus efforts on addressing our most serious global challenges by 2030. Whereas their predecessors, the Millennium Development Goals (MDGs) of 2000, made no mention of energy, the SDGs include Goal 7 (SDG 7): "ensure access to affordable, reliable, sustainable and modern energy for all". As the World Bank points out, energy is a crucial contributor to the realisation of the other sixteen goals [1]. Empirical evidence gathered in Indian slums by Parikh et al. [2] supports the belief that basic energy provision is a key developmental building block. Grid-electricity arguably remains the preferred route to SDG 7 for urban and peri-urban citizens, notwithstanding the significant challenges in de-carbonising national grids. But the growth of Africa's under-served urban informal settlements often outpaces the financial and practical ability of individual governments to connect these communities to centralised energy systems (and keep them connected). In rural areas, off-grid Solar Home Systems (SHSs) have enabled impressive advances in basic electricity access notwithstanding the deficiencies of SHS in providing a full energy service (including cooking), as argued by Monyei et al. [3].

However, even as an entry-level clean-energy service (for lighting and media only), the array of state-led, donor-led and market-led SHS initiatives fail to ensure the *universality* of affordable access envisaged in SDG 7. Thus, treating SHS as an evolving technology that can, for now, partially contribute to the challenge of universal access to clean,

* Corresponding author.
E-mail addresses: damian.conway@ishackproject.org.za (D. Conway), blake@sustainabilityinstitute.net (B. Robinson), pmudimu@mweb.co.zw (P. Mudimu), tchitekwe@gmail.com (T. Chitekwe), kkoranteng@sun.ac.za (K. Koranteng), Mark.Swilling@spl.sun.ac.za (M. Swilling).

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modern and affordable energy, this paper explores how elements from the fairly distinct existing delivery approaches might be combined to produce a more scalable, equitable model for delivering basic but durable energy services to informal urban settlements via SHSs.

Specifically, we investigate a South African and a Zimbabwean case study that each represent different implementation models for providing SHS services in urban informal settlements. Both models are focused on the challenge of universal access, however the former takes an enterprise- and operations-focused approach, whereas the latter is based on social processes. The respective strengths and weaknesses of each approach are examined, and possible synergies between the two are suggested, in response to a call for more effective 'hybrid' models in the literature. Our proposal is for a proliferation of competing state-subsidised 'social enterprises', working in partnership with civil society organisations. The funding, finance, revenue and subsidy ratios of these partnerships should evolve over time but should aim to incorporate some commercial elements from the beginning in order to attract investment and unlock the cost-efficiencies that typically flow from competition, in combination with subsidies or grants to ensure that the poorest members of a community are not excluded. The model should also incorporate – in a carefully planned and coordinated fashion – a partnership with at least one community-based organisation that supports and builds the capacities of the target communities, disseminates information, embeds technical literacy, intermediates on payment defaults and supports user-groups to access more of the commercial aspects of the service via peer-mediated savings and loan schemes.

2. Methodology

The methodology that was adopted for this paper stems from a transdisciplinary research approach called Emergent Transdisciplinary Design Research (ETDR), [4]. ETDR emerged in 2011 when students who were enrolled in a Masters Programme in Sustainable Development at Stellenbosch University decided to engage the Enkanini informal settlement (where the iShack Project now operates). There were no organised stakeholder formations to represent the community. This made it difficult to implement traditional transdisciplinary research methods which generally tend to emphasize the importance of engaging with stakeholders [5]. Instead of abandoning the exercise, the students pioneered an informal way of relationship building with small networks of individuals. Over time, these informal links led to conversations about the most pressing challenges in the community [6]. The result was the emergence of a clear set of energy-related needs: people needed energy but there was no grid connection, because candles and kerosene lamps were widely use the threat of fires was high [7]. This early research ultimately led to the establishment of the iShack Project as a large scale off-grid energy utility which is case studied in this paper.

The impetus for the writing of this paper was the existence of the two case-study projects and about which the authors have a detailed working knowledge. The two organisations that initiated these two projects, have, over the years, committed to collaborating on the co-development of a solar energy delivery model, but have so far pursued their own models with their own specific and contrasting approaches. The collaboration on this paper presented an opportunity to first explore the 'state-of the art' in the literature regarding the range of other models of delivery in SSA and then to critique the two case-studies, firstly through the lens of the literature findings, and then in contrast with each other. Overlaying this framework, the ETDR transdisciplinary research approach was used where possible. The authors include university-based researchers trained in transdisciplinary research methods and the practitioners working directly on the energy services projects. The research team concentrated on qualitative information drawn from interviews and many formal and informal group discussions with project managers, community workers and end-users. Where available, empirical data and financial information on both projects was synthesised to substantiate claims of successes or failures. Consistent with the ETDR approach, the aim was to produce useful knowledge for those engaged in social change [8] as well as knowledge that contributes to the wider academic understanding of incrementalism [9] within the context of informal urbanism in African cities [10,11].

3. Background

3.1. The growing scale of un-electrified Africa

The African region has the second fastest growing urban population in the world [12], and predictions foresee an increase in African urbanisation levels from about 40% urban in 2014 to 56% at 2050 [12]. In the face of such rapid growth, most African cities are ill-equipped to provide the infrastructure required to ensure a good quality of life for those already living in urban areas, let alone new arrivals. Six hundred million people live without electricity in Africa [13]. Electricity consumption in Sub-Saharan Africa (SSA) is less than that of Spain [14]. The shortage of electricity infrastructure in Africa is undermining efforts to accelerate economic and social development [15], with energy sector bottlenecks estimated to cost the continent 2–4% GDP annually [16]. Africa hosts 19 of the 20 countries with the lowest electrification rates in the world [17], and, in many cases, where electricity tariffs are amongst the highest in the world. For the few who can access the grid, electricity supply is often unreliable, requiring expensive diesel or gasoline generators as back-up [15].

3.2. The informal settlement development gap

More than half of those residing in SSA cities in 2014 lived in 'slums' or 'informal settlements', and the lack of electricity supply in Africa's urban informal settlements has long been recognised as a development gap requiring a concerted effort from governments and the development community [18]. This has been reiterated by the New Urban Agenda [19], which calls for the prevention of new informal settlements and the upgrading of existing ones. Informal settlements are still typically viewed by decision makers as a blight on cities [20], and are typically associated with illegality, crime, poverty, disease and stagnated development. However, they are also spaces of creativity and possibility, which contribute to wider society and the economy [21]. Unfortunately, the delivery of formal services to informal settlements can be politically unpopular since it is seen to legitimise them, and authorities are more likely to focus on alleviating the symptoms of urban poverty than addressing its deeper causes [22]. In addition, residents using informal or illegal energy services may be reticent to upgrade to a formal service, having become accustomed to free electricity [23]. Even when there is a commitment or legal obligation to deliver services, the organic, unplanned nature of informal settlements makes them particularly challenging and expensive contexts in which to retrofit conventional infrastructures. The result is a growing number of communities left without any services for many years and even decades [24–26].

3.3. Basic electricity as a right

While access to an affordable range of energy services is required to meet basic needs, most national constitutions and laws in SSA do not yet recognise the right of access to energy [27]. One of the reasons for this is that many countries' primary laws, and particularly their constitutions, pre-date the international consensus on energy as a development pre-requisite [27]. Constitutions are also deliberately difficult to change; they favour principles over specifics and are generally designed to allow for future interpretation that may give effect to additional rights that are not explicitly provided for in the countries' founding or primary laws. For example, although South Africa's relatively young Constitution, adopted in 1996, makes no mention of a right to energy or electricity, its Constitutional Court ruled in 2010 that electricity is an important basic service and that local government has a constitutional obligation to provide it (see [28]). Indeed, South Africa has an array of laws and policies that not only confirm the state's obligation to provide all with access to energy services, but also require local government to provide its indigent residents with free basic energy [23,29]

Internationally there are a number of (non-binding) agreements and commitments that support the right to energy services [27]. In addition to Goal 7 of the SDGs, Article 16 of the African Charter on Human and Peoples' Rights [30] (the right to the best attainable state of mental and physical health) leads to the logical conclusion that basic services, such as electricity, need to be delivered to give effect to these basic rights. It is likely that developing states will need to start explicitly identifying clean energy as a right in their national laws and policies and allocate appropriate funding.

3.4. Bridging the delivery gap: solar home systems

The default assumption that grid connection is the only way to provide affordable energy is an obstacle to basic, incremental energy access in informal settlements. Financial and practical barriers to extending the grid can often leave urban communities un-serviced for decades, when alternatives such as off-grid solar technologies are readily available and increasingly affordable. Although more frequently associated with rural electrification[1], off-grid SHSs or mini-grids are equally suitable for urban informal settlements as a medium-term or even long-term alternative to unaffordable or impractical grid-electrification.

SHSs, in particular, offer a number of benefits that make them well suited to quickly meeting the basic needs of African informal settlement households:

- Solar PV offers the shortest project deployment time of any power generation technology [31,32], making it relatively quick to install and thus more effective in meeting urgent energy needs.
- Off-grid SHSs may be better suited to incremental service delivery than grid-tied centralised solar PV plants [31].
- The installation of a SHS in an informal dwelling does not require a comprehensive upgrading plan for the settlement [7] or rely on other infrastructures such as formal roads or other reticulation networks.
- With insolation levels ranging from 4 to 7 kW h/m2/day, many parts of Africa receive some of the best solar irradiation levels in the world ([33,34]; p20).
- Compared to using liquid fuels or candles for light, SHSs reduce household lighting costs, reduce vulnerability to domestic health and safety hazards, and improve study conditions for children [1].
- Unlike solar lamps, SHSs allow urban informal households to access electricity, often for the first time [7,35]. This enables them to make use of 'modern energy services' as envisaged in SDG 7, such as media, internet, cooling and refrigeration.
- SHSs run efficiently on safe, low-voltage, direct current (DC) [36], thus allowing them to be installed and maintained with a lower level of skill than higher voltage systems. and making the provision of job opportunities in target communities more viable in the short term [37].
- SHSs enable entrepreneurially-minded users to provide services such as mobile phone charging, barber shops, small grocery shops [38] and potentially stimulate demand for other products and services.

With growing numbers of international SHS developers and suppliers competing for business, there has been significant technical innovation over the past decade, producing increasingly sophisticated and cost-competitive hardware options [39]. These innovations include:

- Significantly improved energy management systems (and thus lower running costs due to longer battery life);
- Remote access controls (using mobile phone networks), including the ability to switch-off or reduce the power output if the user fails to make contractual payments;
- The ability to remotely monitor the hourly energy generation and consumption, which improves diagnostic troubleshooting (often negating the need for a technician to have physical access to the system);
- The ability to incrementally upgrade a system with additional generation and storage capacity to power additional appliances.

Despite these advances in functionality, the hardware costs continue to drop steadily [40] thus making SHSs an increasingly cost-effective preliminary infrastructure investment [23]. The future arrival of the grid does not necessarily make SHSs redundant: As seen in Bangladesh, most households who had previously received subsidised SHSs under a state-funded program, preferred to keep their system even after the grid arrived, despite a SHS buy-back guarantee [1].

It is worth noting that SHSs are not the only viable alternative to grid electricity in informal settlements. For example, solar mini-grids improve energy storage efficiency by centralising the generation and storage of solar electricity and distributing the metered electricity to clusters of households. Also, whereas SHSs normally provide DC power (which can limit a household's appliance choices), it is more feasible for larger mini-grids to provide AC power, allowing for greater versatility and a wider range of economic development opportunities. The ability to expand generation capacity, and to integrate with the grid in the future, make mini-grids an attractive longer-term option. Indeed, the International Energy Agency predicts that by 2040 140 million people in SSA will receive electricity from mini-grids, compared to 80 million from SHSs [15]. These predictions do however seem ambitious given that there were only approximately 150 commercial mini-grids in SSA in 2017 [41].

The slow proliferation of mini-grids thus far underscores some of the barriers to entry. For example, the investment return on a mini-grid typically comes from the long-term sale of electricity, compared to the financed sale and maintenance of SHS hardware to households over 2–3 years. Thus, the investment case for mini-grids requires far more certainty about financial viability in the longer term, which is often not the case in SSA [42]. Also, only relatively stable settlements with well-established land-use arrangements are suitable; the mini-grid infrastructure needs to be located on a secure site, and the safe and secure reticulation of electricity requires a level of planning and regulatory compliance that further impedes speedy deployment. Mini-grids are also less likely than SHSs to create jobs in the community; the hardware and metering software is more sophisticated, and the higher voltage electricity reticulation is less safe, requiring a higher level of technical competence and regulation.

Notwithstanding the increasingly important role that mini-grids will play in helping to achieve SDG 7, the focus of this paper is on the contribution that SHSs can make to the medium-term energy needs of unelectrified informal settlements.

3.5. Existing delivery models

By mid-2015, global off-grid pico-solar[2] products represented an

[1] The literature on the use of solar PV in poor communities is predominantly about rural electrification programs, for example [33]; Sandwell et al., 2016; Nygaard, 2009.

[2] Pico-solar PV systems include solar lanterns (stand-alone devices with a PV

annual market of USD 300 million [43]. Sub-Saharan Africa (Kenya and Tanzania in particular) is the largest market for off-grid solar products with 1.37 million units sold, followed by South Asia (1.28 million units sold) [1]. Nevertheless, SHSs (as opposed to smaller solar-light systems) still represent less than 5% of the off-grid solar market by number of products sold as of June 2016 [43], and the deployment of SHSs is particularly low in urban informal settlements.

The delivery of SHSs to poor communities is typically driven by donor-led, government-led or market-led programmes, or a combination of these. While donor-led projects can be very useful as a means of experimentation and demonstrating models that could later be adopted or supported by the state such programmes tend to be unsustainable at scale or in the long term. This leaves government-led or private-led models to take up the mantle of achieving universal access.

3.5.1. Government-led programmes

Although national laws and policies generally lag international commitments towards achieving universal energy access, there have been many government programmes aimed at this goal. One example is the South African rural electrification 'Concession' programme launched in the early 2000s. Private companies were awarded government concessions to install SHSs in rural households in designated territories. The national department of energy funded 80% of the hardware costs and the concessionaries were expected to recover the rest from the end-users. Similarly, local municipalities were expected to contribute a small operations and maintenance (O&M) subsidy to augment ongoing maintenance co-payments from the end-users. Although more than 46,000 households across South Africa were reported to have received SHSs by 2012, this fell well short of the original target of 300,000. Unreliable O&M subsidies and erratic end-user payments have jeopardised the sustainability of the service, and the front-loading of income for each concessionaire may have disincentivised them to invest in the capacity and business infrastructure necessary to provide a longer-term utility service. It has reportedly also not helped that the concessionaires were not kept informed of the government's subsequent grid-electrification plans. This has undermined a willingness to invest in the concession business as a long-term energy utility [42].

While the failings of the South African rural concession programme could arguably be resolved by making adjustments to the funding and contracting model, there remain certain fundamental problems that are more difficult to address. Rehman et al. [44] and, before them, Van der Vleuten et al. [45] highlight the risk of misappropriated or misdirected funds, as well as the tendency of large state-funded contracts to crowd out local competition and entrepreneurship. Van der Vleuten et al. cite examples in Morocco and Kenya where massive state-subsidised projects have seriously curtailed local competition. A further problem with 'top-down', government programmes is the potential political push-back from end-users, particularly in urban communities, who may expect grid electricity as the minimum standard. Ironically, a subsidised government programme may, in certain contexts, see more resistance than a purely market-driven approach, where households are individually free to choose (and pay for) an alternative energy service without feeling that they are relinquishing their rights to a higher standard of state-provided electricity in future. In South Africa, in particular, municipalities have a legal obligation to provide energy as a basic service, regardless of the legality of the actual settlement in question. Therefore, the above-mentioned 'depoliticisation' via private provision may open up the opportunity for the state to subsidise market-driven off-grid services, where the subsidy-terms compel the private enterprises to deliver prescribed minimum energy standards while allowing them to market voluntary add-on services or upgrades. In this way the state is able to deliver, at least partially, on its development mandate, while pursuing more sustainable long-term solutions to the legitimate barriers to land tenure.

3.5.2. Market-led approach

There has been significant growth in the market-driven roll-out of SHSs, particularly in rural SSA [46]. This growth has mostly been led by for-profit technology companies that have benefited from significant financial support provided by development agencies, non-governmental organizations (NGOs), foundations, governments, and so-called 'impact investors'. With this 'market development' backing, technology companies have been able to provide the end-user finance that allows customers to pay off the full cost of their systems over two to three years. Practically, this has also been facilitated by the increased use of 'mobile money' in the region, which has enabled the structuring of flexible 'Pay-As-You-Go' (PAYG) schemes and also created a powerful basis for long term transactional relationships between the commercial entities and customers [47,48].

The benefits of a market framework include rapid technological innovation, cost-competitiveness, greater choice for end-users, quality assurance and customer-oriented service. Crucially, a commercial approach provides the impetus for the establishment of longer term maintenance facilities – an aspect of SHS provision that is essential for the long term sustainability of an electrification initiative [44,45,49]. Businesses that hope to develop their customers for long-term revenue streams (including maintenance, upgrades, new product-lines and services) have invested in local operations and systems that, in turn, build trust and confidence amongst potential customers. These business systems, though expensive to implement, also help to introduce efficiencies and economies of scale in the long term. In turn, these efficiencies help to reduce product and service costs and also provide a platform for local job creation and green skills development.

The ability of a commercial venture to realise these benefits depends on its scale. Rehman et al. [44] point to numerous examples (in Zimbabwe, South Africa, Bangladesh and Sri Lanka) that suggest a larger scale of enterprise is required to be sustainable, and that smaller 'bottom up' enterprises are often unviable due to deficiencies in external support, technical skills, finance and infrastructure.

Although powerful as drivers of scale, purely commercial initiatives still fail to enable *universal* access due to profit maximisation and a focus on areas that provide lower risks and better financial returns [44,50,51]. Although Van der Vleuten et al. [45] are strongly in favour of market-based approaches, they acknowledge that they tend to exclude the poorest households, who are most in need of basic energy solutions. Despite a steady decline in SHS costs over the past decade, the upfront costs of SHSs remain prohibitive for the poorest households [1]. Commercial ventures need to charge these upfront costs in order to target only those customers who are more likely to pay reliably. Also, when providing a longer-term, accessible, customer-orientated *energy service* - rather than merely selling hardware - the costs of setting up and sustaining such a sophisticated and widely distributed operation is expensive[3] . This is particularly so when the entire operation is directly funded and controlled by the business.

3.6. A pro-poor hybrid model?

Although the above review is not an exhaustive exploration of the pros and cons of government-, donor- or market-led approaches to SHS deployment, we proceed on the basis of our assessment, supported by Rehman et al. [44], that neither private- nor public-sector-led

(*footnote continued*)
panel to charge them), solar kits (providing more than one light, and often including other services like mobile phone charging), and SHSs (which have a larger PV panel and can power larger appliances such as television) ([1]).

[3] These costs are of course particularly heavy in hard to reach, yet sparsely populated rural markets, whereas a denser, more accessible urban informal settlement would be less expensive to serve.

initiatives have been effective in providing *universal* energy access for the poor with an emphasis on sustained *service delivery*. These authors argue for a 'pro-poor hybrid model' in which social welfare objectives are combined with enterprise development and growth objectives in recognition that purely public or purely private initiatives each have "inherent benefits which may be lacking in the other". Although the 'Public Private Partnership' (PPP) model is a well-established mechanism for harnessing the potential synergies between subsidy-driven and commercial approaches, Rehman et al. identify some problems with how the PPP model is normally implemented, including a very rigid treatment of inputs and outputs through fixed contracts, as well as a disconnect between the motives of the implementing private partner (cost saving and profit maximisation) and the funding public partner (quality improvement, and presumably, delivery targets). The authors make a case for more innovative partnerships which are adaptable to specific contexts and have a focus on service quality.

Rehman et al. [44] believe that effectiveness and efficiency can be maximised "through the involvement of several entities owning and operating different parts of the system". The Lighting a Billion Lives programme is given as an example. Early on in this solar lighting programme it was recognised that, in order to establish market demand, the majority of the cost of solar lights needed to be subsidised. As products became more affordable and demand grew, the programme was able to incorporate more commercial elements in the business plan. This trend was reflected in an evolving funding, finance and ownership structure ranging from 90:10 grant:equity to 60:30:10 grant:equity:-debt. Also, the context informed the respective roles and level of participation of government, business, civil society, manufacturers, local entrepreneurs and financial institutions [44].

Going beyond flexible ownership and funding structures, Rehman et al. [44] also make a strong case for the integral role that civil society organisations can play in a model that seeks a symbiotic relationship between commercial and social-inclusion objectives:

> "Civil society organisations have a critical role to play in generating awareness amongst members of the community which are normally marginalized or ignored by conventional communication channels. In the case of pure market actors, the costs of effectively communicating a message about the benefits can be a difficult barrier to overcome."

This view is echoed by Scott [52] who stresses the importance of trust and information sharing via partnerships with local organisations that rely on informal institutions and networks. Taking this idea further, it seems likely that civil society organisations that have such relationships within the communities that they work would be able to contribute even more than merely disseminating information.

Our interest is the potential of Rehman et al.'s hybrid concept for the delivery of a rights-based energy service to residents of informal settlements in SSA. In particular, we wish to explore the viability of a model that fits into the paradigm of basic '*service-delivery*'; that is, a model that incorporates some level of state-level funding (or, as proxy, donor funding that models the anticipated future financial support of the state) in recognition of basic energy as a universal right. In the following section we present two SHS case studies. The first is the iShack Project in South Africa which has attempted to incorporate some hybrid elements, namely an adaptive, flexible model and funding arrangement for the provision of state-subsidised SHS services to the urban poor by focusing on operating systems and enterprise efficiencies. We explore how this model improves operational effectiveness and efficiencies and we identify aspects that could be further 'hybridised' to better meet social goals. The second case study showcases a SHS project led by a consortium of civil society organisations working in the Dzivarasekwa informal settlement in Zimbabwe. This project works closely with the community to establish practical social processes and rituals that promote peer-to-peer accountability amongst households who secure loans for purchasing SHSs. We then discuss how group-based social processes and wider community engagements could be combined with business systems and procedures to shape new, more effective state-subsidised approaches.

4. Case studies

South Africa and Zimbabwe share common challenges around electricity access, affordability and safety amongst their poor urban dwellers. Typical of the SSA region, both countries have large urban populations living in informal settlements with inadequate access to modern energy services. In South Africa 7.1% and in Zimbabwe 14.5% [53]. South African law recognises the rights of informal settlement residents to basic energy services, whereas informal settlements are considered illegal in Zimbabwe and thus ineligible for state electrification.

4.1. iShack Project, South Africa

The iShack Project is a not-for-profit business that was established to roll out SHSs in an informal settlement called Enkanini in Stellenbosch, South Africa. The project was established in 2012 as a social enterprise following a number of years of applied research into the challenges of informal settlement upgrading by the Sustainability Institute and Stellenbosch University addressing the question "*What can be done while residents of informal settlements wait for state-provision of conventional service delivery?"*. The purpose of the project has been twofold:

- to develop and demonstrate, at scale, a financially and operationally sustainable model for the cost-effective delivery of off-grid solar electricity to informal settlement residents;
- to capture opportunities for economic multipliers that benefit the target community through the delivery of the service (e.g. local job creation and skills training).

The iShack Project was set up with capital funding from a 'green economy' government grant and currently serves over 1600 households with a solar energy service that provides power for lighting (3–4 lights per household) and media (television, radios, cell-phones) using standalone 50-75Wp SHSs. The local municipality provides an operations and maintenance subsidy per household (via a public-private partnership contract with the iShack Project), which covers up to 90% of the utility's overhead costs. Thus, in line with the principle of basic energy as a right, both the capital and the ongoing operations costs of the service are largely subsidised by the state in order to make the service as accessible and affordable as possible to indigent households. However, to access the service, each household is required to enter a contract with the iShack business, pay a joining fee and make co-payments towards the ongoing maintenance costs. These co-payments help to establish a clear transactional relationship between the project and the end-users. To some extent this helps to 'depoliticise' the service, as end-users have to individually opt into the service by making a financial commitment rather than it being provided purely as a government hand-out to households on a waiting list. It also serves to establish some accountability for service quality by the business, as well as provides a platform for offering more commercially priced products and services such as appliances and system upgrades.

Since inception, the project has adopted a financially and operationally flexible 'continuous improvement' approach to implementation. The adaptive design framework is aimed at providing a fit-for-purpose service via a financially efficient operation. Thus, the management team have continually developed evolving operating systems including written procedures, policies and plans for dealing with everything from contracting a new client to technical maintenance and troubleshooting protocols, to responding to payment defaults in a consistent and fair way. The implementation of these systems is monitored and recorded, electronically and at a high level of resolution, on a purpose built online client-management platform.

The data-rich, continuous improvement approach has enabled the project to become more resilient and efficient, ensuring an appropriate fit for the challenging context. Some of the key challenges and set-backs that the project has encountered include the following:

- **Technology:** Shortcomings with the initial hardware resulted in a high fault rate and allowed for easy tampering to by-pass payment controls. This not only made it difficult to secure reliable revenues, but required a significant amount of maintenance support. Initially, the response was to adjust the pricing options to allow for more flexible Pay-As-You-Go (PAYG) payments, but ultimately it became necessary to source more reliable and affordable hardware. This technology change, coupled with additional changes to the pricing model (see below) made ongoing switching controls less important and tampering less prevalent. As a result, the overall maintenance demand has been reduced by more than 50%.
- **Skills development, job-creation and enterprise development:** The project started by recruiting a group of five residents who were trained to be 'iShack Agents'. The idea was that these trainees would eventually become semi-independent 'micro-franchisees', earning commission-based incomes (with modest monthly guarantees). However, the growing maintenance load, coupled with a general dissatisfaction with variable monthly incomes eventually resulted in the Agents downing tools. The project responded by shifting to a more conventional employment arrangement with more limited performance incentives. There are currently four full-time 'maintenance' Agents and a small group of installers who are contracted on an *ad hoc* basis and paid per installation. The new employment arrangement has been effective and stable since early 2015. Many of the operational systems in the project have been developed in collaboration with the iShack Agents who receive ongoing (weekly) training and performance monitoring on these systems to build a culture of ownership, quality assurance and accountability.
- **Pricing:** Initially all households that opted into the service were required to pay a fixed monthly service fee to use the SHS (including a TV) and receive free maintenance and free battery replacement. Although there was a relatively high rate of payment compliance during the first year, the growing rate of technical faults coupled with the ease of tampering, resulted in a gradual deterioration in revenues. To avoid clients falling into arrears, the project then introduced the PAYG option, allowing for more irregular payments. However, this still left households without lighting and media at different times throughout the year which undermined the intended social and health benefits of the service.
  Since the start of the project, the intention was to secure an operations and maintenance subsidy from local government as a key part of the business model. This was achieved eighteen months into the roll-out, and enabled the project to introduce more flexible payment options for end-users. Thus, the majority of the 1600 clients are now on a so-called 'Free Basic' service which can be accessed by paying a modest installation fee and deposit, but carries no fees to access the electricity. Further co-payments are only required for maintenance and battery replacement (if and when needed). This Free Basic provision is in line with South Africa's policies for indigent support [refs: FBE Policy, SEA Policy Brief]. At the current scale of the utility, the combined revenues are sufficient to sustain the ongoing maintenance service, and yet the cost to the municipality is significantly lower than the cost of maintaining grid connections. Importantly, the financial model was never intended to generate sufficient revenue to recover the capital cost of the hardware. The hardware was grant funded to demonstrate to the state the cost-benefit of this kind of basic service delivery model.
- **Protest Action:** Eighteen months after the launch of the project, a small group of residents vandalised the iShack Hub following a large service delivery protest in central Stellenbosch. Significant damage was done to the project's operational base in Enkanini and a large quantity of stock was either stolen or destroyed. Although subsequent conversations with members of the community suggested that there was little support for this action, the community made no attempt to stop the vandalism and no culprits were named. This event, coupled with the ongoing challenges with hardware maintenance and revenue collection resulted in the immediate suspension of the project roll-out, and six months were spent researching alternative hardware options and developing the 'Free Basic' pricing model before re-launching towards the end of 2015.

The iShack Project's freedom to experiment, innovate and adapt has been made possible by the deliberately flexible funding terms, delivery targets and implementation plans allowed by the project's funders, including the service-level agreement with the local municipality. This has given the project the space and time to develop a durable service that minimises exclusion on financial grounds and provides a platform for additional commercial products and services.

Having weathered numerous challenges and set-backs, the energy utility is now financially sustainable, providing a cost-effective high-quality maintenance service. Nevertheless, the challenges described above reveal that the strong focus on continuous improvement, quality systems and operational efficiencies were not always sufficient to shield the project from significant shocks and set-backs. While the responses to these challenges may have helped produce a more resilient and sustainable model, further adaptation may still be necessary to avoid ongoing political and financial vulnerabilities and to capture additional benefits for the project and the community. One area where this might be achieved is through a more meaningful and representative engagement with the community.

4.2. *Dzivarasekwa Community Participation in Clean Energy Delivery, Zimbabwe*

This case study focuses on a SHS project in the Dzivarasekwa Extension, a former holding/transit camp of 480 un-electrified households established in 1991 on the periphery of Harare. The settlement is currently being upgraded through a partnership of civil society organisations known as 'the Alliance', including Dialogue on Shelter Trust (DOST), the Zimbabwe Homeless People's Federation (ZHPF) and Shack Dwellers International (SDI). The Alliance is working in cooperation with the City of Harare to provide SHSs to households on a group savings and loan basis. The longer-term objective is to leverage the capacity established during the SHS scheme to mobilise the community to lobby government for improved access to other affordable services.

The SHS project was launched in 2016 and has involved community members in all stages of project development, including information dissemination, installations and maintenance and managing group savings and loan schemes. The 'Federation Model' [54], championed by SDI, has been adopted to mobilise residents via savings groups which provide horizontally accountable support to apply for and repay group loans.

Following devastating shack fires in Dzivarasekwa in 2014, the Alliance assisted the community to learn more about SHSs for safer lighting options. A wide array of products was assessed by the community, the majority of which were rejected as sub-standard. Having narrowed down the technical options to two SHSs, a loan scheme was established to provide affordable finance for households to buy their own SHSs.

The project has not been established as a separate business or legal entity, but personnel from the respective Alliance partners have been seconded to the project in order to provide financial, technical, operational and oversight capacity and support. Also, central to the implementation plan is the training of community members on all technical aspects of delivery. A 21-member team has been established, including 3 mobilisers, 15 technicians, 2 loan officers and a representative from the Gungano Urban Poor Fund which provides the loan finance.

The project offers two different SHS options: a 6 Wp system that powers 3 lights and cellphone charging, and a 200 Wp 'entertainment' system that can power a radio, TV or computer as well as cell phone charging and up to 10 lights. The systems are priced with a mark-up on the unit cost to cover installation and other costs. The entertainment system price includes an extra margin to cross-subsidise the 6 W system. The ratio of 6 W systems to 200 W systems is approximately 15:1. No interest is charged on the loans and there is no overall profit margin.

After passing a basic vetting process, a household can get a loan if it is a member of one of the community Savings Groups (minimum 20 members). Households are also incentivised - with more favourable loan terms – to join a 'Solidarity Loan Group' (minimum 5 members). The loan scheme is based on a 'revolving fund' principle; loan repayments return to the fund to provide new loans for new participants. Although each participant is required to sign a contract, there is room for repayment flexibility in recognition of the unpredictability and vulnerability of the households' circumstances. For example, in response to hyperinflation in 2006, the Fund allowed repayments to be made in the form of building materials instead of cash. The project encourages women-led savings and loan groups, and has generally found this to be an effective approach.

Eligible savings groups must be able to demonstrate their managerial and organisational capacity; they must have a savings scheme constitution and consistency in savings, conduct regular minuted meetings with an attendance register. Also, loan group members pay a 50% lower joining deposit if their group has sufficient savings to cover at least one month's instalment per group member. This is held as security to be used in the event of default by any one of the group's members. Loan officers receive a commission of 5% on all collections, thus incentivising them to ensure that loans are repaid. As a last resort, provision is made in the loan contract for repossession of a system in the case of repeated failure to pay.

Trained community members are engaged as technicians to scope, install, repair, and maintain the solar systems, and to educate new users on how to use them. They receive a flat fee from the project per installation, and they are also privately engaged by households on a more informal basis for maintenance and repairs. Although the technicians are coordinated, managed and monitored through the Alliance's structures, they are not permanently employed by the project.

Of the 480 households in Dzivarasekwa, approximately a quarter have signed up for the loan scheme to-date, and 85% of these via Solidarity Loan Groups. Early signs are that the group loans have been very successful in terms of repayment compliance. Since commencing the roll-out in 2016, 95% of all due payments have been made monthly, so loan rescheduling[4] or repossessions have not yet been required.

The project organisers have observed that both the Savings and Solidarity Loan Group meetings provide captive and engaged audiences for the promotion of SHS offerings, and help to strengthen and grow the groups. As effective as they are in mitigating loan defaults, these social structures and rituals are also providing a basis for further community-led development initiatives.

The Dzivarasekwa model is now being replicated by the Alliance in five other settlements in three Zimbabwean cities. The national target is 1325 households and 651 have accessed the SHS loan scheme so far. Similar to the iShack Project experience, there have been various policy and operational changes to the model in response to the inevitable setbacks and challenges of implementation. However, the deliberately flexible, adaptive approach taken by the Alliance partners has enabled effective incremental improvements to the model over time. Nevertheless, there remain some financial and operational deficiencies that may constitute more fundamental obstacles to the scalability of the current model:

- **Financial Scalability:** A shortage of working capital limits opportunities to scale and replicate the model. Without a profit or loan-finance return it is difficult to attract scaling capital beyond 'demonstration' grants. Consequently, without a high growth rate it is also difficult to provide a steady flow of stock, and so households often have to wait many weeks or longer before receiving their SHS. Also, the cost of running the project is funded from non-recoverable grants rather than costed into the pricing of the SHS or the loan facilities, which is not sustainable. Finally, despite the SHSs effectively being priced very low, the lack of subsidy support from government means that the barrier to entry remains high for most households, and thus, even at the current demonstration scale, the model is unlikely to provide universal access within a single community.
- **Operational Capacity:** Notwithstanding the promising efforts to support informal 'green-economy' entrepreneurship, there is no security of income or employment for the technicians. In the model's current form, it can at best provide a modest side-income for a few of the community members in the medium term. The durability of the project as a longer-term energy service (as opposed to a simpler SHS sales and installation service) is limited. The project does not have an energy-service business plan, and the operational personnel have been seconded from, and paid for by the partner organisations. Operating systems, record keeping and data management, procedures and policies for dealing with clients (as long-term energy clients) are all limited. Thus, responses to complaints are often slow and day-to-day operations can be inefficient or inconsistent. Poor communication between the technicians has been observed by project overseers. There is also no plan in place to assist clients with replacing faulty components or periodically exchanging batteries.

5. Discussion

Although the iShack Project embodies some of the intended synergies and benefits of Rehman et al.'s hybrid model proposition, the project is not a complete exemplar of their vision. They highlight the important role that civil society organisations, working in communities, can play in enhancing the effectiveness of energy initiatives. In particular, they and others [45,52,55] point out that these organisations can work with communities to disseminate information and understanding about energy technologies; a critical element of a successful business, which when undertaken solely by the energy business or project can be very expensive. Also, this information is likely to be more trusted when disseminated by more impartial civil society organisations, particularly in the case of technologies like SHSs, which can suffer negative perceptions based on previous negative exposure to substandard products, or in countries like South Africa, be distrusted as an inferior alternative to grid-electricity.

Building on this, it appears that organisations that have established relationships with target communities would also have a role to play at an ongoing operational level, in the case of the iShack Project there are at least four areas where a formal or informal partnership with a well-established community organisation might help to further improve the effectiveness and efficiency of the energy service, which in turn can have a direct impact on affordability and equity of access:

- **Imparting and embedding technical literacy.** Community exchanges and horizontal learning programmes can be enormously effective in building technical understanding as well as trust, particularly when different communities are able to visit SHS demonstration sites. However, this need for knowledge transfer goes

[4] It has been the Fund's practice to reschedule loans to allow for repayment over longer time periods when necessary before instituting other recovery measures

beyond simply establishing an informed acceptance of the technology; community organisations can provide an invaluable role in supporting user-groups to build and share 'user-knowledge', inculcating responsible technology use (e.g. optimising battery-life or troubleshooting technical problems). Building these networks outside of the operational control (and budget) of the implementing business could bring considerable savings for the project and the end-users.

- **Supporting and capacitating internally accountable 'user-groups'**. Although there are technical options for enforcing payment compliance (e.g. switching off or limiting electricity access) and a growing database of information on the 'credit-worthiness' of each client, the iShack Project has no recourse to the wider community or to user-groups when payment defaults occur or when technology is misused or abused. The ability to invoke group-mediated interventions in response to contractual breaches could significantly improve over-all compliance.
- **Intermediating between the community and the project** in addressing unexpected set-backs and helping to find an agreed way forward when such difficulties arise. For example, the negative effects of the worker strike and vandalism might have been substantially reduced, if not entirely avoided if the project had been able to turn to some kind of community representative body or intermediary for support and even for physical defence of the facilities under attack.
- **Intermediating between the community and local government** to contest for sufficient subsidy support. While the iShack Project has to-date played this role, a more impactful approach would be for communities to organise themselves to place direct pressure on local government to subsidise a SHS energy service – even if as a temporary service prior to grid electrification. This democratic capacity is the ultimate objective of the Alliance partners in the Dzivarasekwa project.

Thus, there is room to build on the iShack model by establishing working partnerships with one or more social partners or civil society organisations that have shared values and similar objectives. While the Dzivarasekwa project may not have the operational systems or the 'energy-utility' approach of the iShack Project it has, in line with Rehman et al.'s general idea, robust social processes, including savings- and loan-groups as well as an over-arching objective of developing democratic and organisational capacity, all of which provide compelling mechanisms for filling the above-mentioned gaps in the current iShack model.

The Dzivarasekwa model could, in turn, benefit from incorporating the enterprise-management, systems and subsidised cost-recovery approach of the iShack Project, which would reduce dependence on long-term donor funding, consolidate the intervention as a sustainable, more accessible (and scalable) energy service, and improve the job security and skills-capacity of the technicians.

The question remains how would such a partnership be structured? What 'stake' would the civil society organisation have in the project? Would the arrangements be formalised and how would the respective partners retain a high degree of independence? Importantly, who pays for what? Again, taking the lead from Rehman et al., perhaps it is sufficient to structure such arrangements on a flexible, adaptive basis that can evolve as the partnership matures. Nevertheless, it would be important to come to a very clear up-front agreement on the shared objectives as well as the specifics of each partner's role, if not their 'deliverables'. Financially it would seem that the commercial aspect of the project should make some contribution towards the project-specific running costs of the social partner so that these costs can be factored into a replicable business model. After all, the rationale for the partnership is that the added value provided by the social partner would cost less than what could be achieved by the business on its own. Nevertheless, in order to retain its independence and trust within communities, it is likely that the social partners would need to continue accessing most of their funding from sources that are independent of the project and which mandate longer-term developmental goals.

6. Conclusions

The use of renewable, off-grid technologies, such as SHSs can drastically speed up the process of upgrading informal settlements. However, the recent proliferation of SHSs in rural SSA has contributed to some negative perceptions about the technology, especially when sales are not backed-up with a high quality after-sales maintenance support. Also, the high entry costs of SHSs that are priced and financed for profit (i.e. not subsidised) means that commercial ventures are limited in their impact on the poorest of the poor. Conversely, subsidised government-led projects can crowd out positive competitive elements that drive growth and innovation, and can stifle private investments in longer-term energy services.

Thanks to rapid technical advances, the capital and maintenance costs of SHSs are now relatively modest in comparison to the operations and maintenance costs of grid electricity. Thus, SHSs are now a cost-effective way for the state to start contributing to universal energy access in line with the growing international consensus on basic energy as a right and with the SDGs. Together with an operational subsidy from local government, affordable end-user co-payments can ensure the long-term sustainability and maintenance of a basic energy service using SHSs. This then provides a solid basis upon which the service can later be incrementally upgraded.

By delivering such a subsidised energy service via flexible and adaptive partnerships between the state, enterprises (for-profit and/or not-for-profit) and civil society organisations, each household's voluntary opt-in can help to establish political buy-in from target communities who might otherwise collectively object to the service as an inferior alternative to grid connection. Furthermore, end-users are more likely to keep using and paying for the service if pricing and payment options are flexible and convenient, and if payment defaults can, to some extent, be intermediated at community level via well-established social processes and networks (e.g. savings and loan groups). Such social processes are likely to reinforce a sense of social contract and responsibility amongst users. This socially-mediated financial resilience can be further enhanced through the implementation of efficient business-orientated operating systems to ensure that costs are minimized and therefore affordability maximized. The social processes can, in turn, reduce costs by relieving the enterprise of the need to invest heavily in marketing, technical literacy and default debt collection. These synergies should translate to lower overall running costs and hence lower product pricing and improved access to the service.

The iShack and Dzivarasekwa projects share a common goal of universal access to basic, clean electricity in poor, under-served urban communities. The reciprocal strengths and weaknesses of these two projects brings into relief the opportunity for symbiotic partnerships in future.

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