

Female microenterprise creation,  
gender and welfare impacts, and  
business models for low-cost off-grid  
renewable energy: Multiple  
randomised experiments

Scoping study report

University of Cape Town

Innovations for Poverty Action



## Colophon

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Scoping Study Report RA5 ENERGIA GENDER AND ENERGY RESEARCH PROGRAMME; Building the evidence base for improving energy interventions' effectiveness by taking a gender approach

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## 1 Project Overview

Extreme poverty and global warming are, arguably, two of the most important challenges facing the world today. Women and girls are often the worst victims of the two, with gender inequality being an added challenge. This research merges the themes of energy, gender, and poverty to study how such inequalities can be overcome by bringing women to the forefront in the establishment of village level enterprises that distribute and recharge LED lights, and mobile phones, to rural poor households, living off the national electricity grid in Rwanda.

Starting from an early age boys are given a higher priority over girls to receive an education, or form an identity outside of their family. This – among other factors – puts women at a disadvantage when it comes to accessing labour opportunities and unfairly places onto them a high level of domestic responsibility that might further limit their ability for economic participation. With this research, we study how these inequalities in gender roles and perceptions can be overcome by bringing women to the forefront in the establishment of local village-level enterprises that distribute LED lights to rural poor households, living off the national electricity grid in Rwanda. Beyond the impact on the livelihood of the potential female entrepreneurs, we also hope to identify broader spillovers into the household ethos including access to lighting within the family and, household expenditure and decision making patterns as they relate to gender.

The viability of most enterprises offering clean, renewable energy products has been severely limited by the pricing of such products and the financing mechanisms available to end users (which may be differentiated in needs and preferences when it comes to gender). Behavioural aspects - such as inconvenience associated with use - represent further barriers to the uptake and continued use of these technologies and may affect men and women differently. Through the village level enterprises that we will be studying, we will also investigate the optimisation of different business models through a number of carefully designed financial and behavioural interventions targeted at different user groups.

Furthermore, in developing countries, the gender divide is rather defined as access to education and credit, and labour opportunities are often imbedded in traditional and cultural norms that give preferential treatment to men and boys. As a result, women and girls are left responsible for most energy intensive activities within the household, which include cooking, cleaning, and being a general caretaker for members of family which once again renders them the main victims of indoor air pollution. We aim to shift this imbalance by making the benefits of lighting and mobile phone charging accessible to everyone.

The project is led by the Environmental Economics Policy Research Unit at the University of Cape Town and Innovations for Poverty Action, a leading international NGO specialising in randomised evaluations. The research is funded primarily by the UK government's Department for International Development through the ENERGIA Gender and Energy Research programme, but also: Grand Challenges Canada, Stars in Global Health; the International Growth Centre; and INSEAD. Funding for equipment is provided by the Finnish government's Energy and Environment Partnership, among others.

We also partner with Nuru Energy (Nuru), a for-profit social enterprise, with operations in Rwanda, and elsewhere, that aims to address the global issue of energy poverty through the provision of low-cost solar mobile phone and light recharging centres providing energy via local village enterprises.

Nuru also designs and manufactures small LED lights that are distributed and sold to households in rural communities.

Using large-scale randomised control trials that blend both qualitative and quantitative methods, this research designs, tests, and evaluates business models specifically aimed at empowering local female entrepreneurs in both their communities, and in the energy industry. Our research rigorously studies the lasting welfare and gendered impacts such energy entrepreneurship and empowerment programs could have. We also test how different gender quotas amongst entrepreneur groups impact both performance and profitability. We further test, and evaluate strategies that increase the adoption and sustained use of household renewable energy technologies. Lastly, we look at the gender and welfare impacts of tier 1 energy access (as defined by SEA4All, 2013) on poor rural households in off-grid areas, focusing on the implications of improved lighting and access to cell phone charging on men and boys versus women and girls within households.

## 2 Research questions

In this regard, our project, which falls within ENERGIA's Research Area 5, the role of the private sector in scaling up energy access, is designed to answer **five** questions:

1. What are the impacts of our women's energy-entrepreneurship empowerment programme, on both women and their families, including income, health, happiness, welfare, poverty, gender dynamics, prosocial expenditures, and other socioeconomic factors?
2. What are the differences between male, female and mixed Village Level Enterprises in terms of their business operation?
3. How do elements of the business model employed influence adoption and use of rechargeable lights? Our study will systematically compare different pricing options and promotion strategies, with the gender composition of the enterprises a key variable.
4. What effect does having female micro-entrepreneurs as role models have on aspirations – particularly those of young girls?
5. What are the effects for males and females of improved household lighting?

The research strategy combines qualitative and quantitative methods. A scoping study based on qualitative research has provided input for the design of the action-research component of the study. This scoping study mainly consisted of interviews with key stakeholders including the implementing partner, its current clients and local experts in gender issues.

The specific research questions following our objectives are, therefore:

1. To what extent have different renewable lighting businesses endeavoured to empower women compared to men in the way that they have their business models structured? Can/do initiatives aimed at increasing women's participation as entrepreneurs in this industry positively impact business profitability? And, to what extent?
2. How are different business models structured in terms of pricing and behavioural modifications to ensure optimal uptake and usage of renewable lighting technologies by both men and women in rural communities? How does Nuru's business model compare to that of other business enterprises in the renewable energy lighting sector working with poor communities? How can behavioural interventions help to encourage regular usage by clients (and particularly by women) and also to incentivize male and female entrepreneurs respectively to promote uptake and usage? How does responses to financial and behavioural interventions differ between male and female headed households? How does female and male VLE respond differently to financial incentives?
3. Does increased access (specifically for women and children) to renewable lighting have positive health impacts for particularly women and children, as kerosene and other hazardous lighting materials are displaced? What are the welfare impacts of access to renewable lighting for poor households and, what do these impacts look like for women and girls vs. men and boys?

To answer these questions, we will use approaches that include:

- A. Testing new microenterprise models, designed to empower rural women and increase microenterprise effectiveness by pro-actively influencing the gender composition of village-level-enterprises and assessing the performance of these enterprises by gender; whilst also evaluating the specific impact of these interventions on female entrepreneurs and their

families, in terms of expenditures on health, schooling and food and also assessing the impact of female entrepreneurs on girls' aspirations.

- Rigorously test new microenterprise models aimed at empowering poor rural women, through placing them in leading enterprising roles within their communities, and also monitoring microenterprise effectiveness.
  - Evaluate the impact of female enterprises on entrepreneurs' households, including determining whether women spend their business income in a more prosocial way than men (for example, on schooling and health), as well as the potential impacts on girls' norms and aspirations within these female-VLE households.
- B. Testing the optimisation of LED lighting technology-adoption and usage patterns amongst men, but particularly also women and children, via a series of focused interventions aimed at evaluating: i) the role of different pricing structures (different pricing of the lights, recharge pricing and also revenue sharing models), ii) behavioural interventions aimed at improved recharging habits of women and men and iii) behavioural interventions targeting both liquidity constraints (which is often a problem for female headed households) and also iv) improved convenience (such as door-to-door recharging services) from the potential customer's (males and females respectively) perspective; and from the VLE's perspective (where again this may vary by gender of the VLE): v) interventions aimed at incentivising sales through differing reward/incentive structures. In each case differential responses based on gender will also be assessed.
- Estimate how adoption and usage responds to pricing amongst different user groups, as well as how this interacts with the gender composition of microenterprises: experimentally calculate the price elasticity of demand and therefore demand curves – the most important relationship for any business.
  - Test behavioural strategies targeted at increasing use (amongst different user groups such as males, females and children), including reducing inconvenience costs of charging and habit-forming behavioural nudges.
  - Determine what makes a microenterprise successful: This really will attempt to summarise the ambit of interventions we are testing to improve Nuru's current business model and making it accessible to a wider user group (including women and children in households). We will study the effectiveness of influencing the composition of VLEs in terms of gender and how this interacts with other interventions.
- C. Quantitatively evaluating, via household level surveys, the impact of providing tier1-level, low-cost renewable off-grid lighting and mobile phone charging on household wellbeing, with a specific focus on the gendered socio-economic and welfare implications for men, women, and children in affected households.
- Conduct a gender focused evaluation of the general impacts of this new model on intra-household activities, time-use, expenditures, savings, reduced pollutants, general wellbeing, health, and allocated studying time for girls.
  - Aim to shed light on community level determinants (amongst all user groups) of technology uptake by gathering large-scale data to identify household (male and female) and community characteristics that support or hinder the adoption and use of LEDs. (Basic data on the characteristics of customers, and kerosene and other

lighting-use and expenditures, is currently lacking, which makes it difficult to design effective distribution models).

- D. Conducting stakeholder interviews with a range of businesses in the renewable energy sector that target low-income households in developing countries in Africa, primarily, and around the world and also using a gendered lens to assess the structure of these models.
- E. Collaborating with other stakeholders in the solar lighting sector by sharing empirical data which will allow for drawing comparisons between business models with specific focus on financial, behavioural- and gender-focused models. We may also supplement this by conducting small scale business model tests and/or semi-structured interviews with households/villages serviced by above mentioned stakeholders.



### 3 Replicability and Generalizability

The research questions pertaining to optimal pricing and behavioural interventions to facilitate take-up, gender dynamics and impacts, as well as, gender empowerment within enterprise development, are relevant to a broad literature on renewable technology and the findings will therefore be generalisable or at least give impetus for extending the research to a broader group of stakeholders.

In terms of optimal pricing, given the programme's focus on households (and specifically women and children) at the bottom-of-the-pyramid in rural off-grid areas, who cannot generally afford renewable lighting products (such as solar lanterns and solar home systems) at market prices, it is crucially important to understand how variations in pricing could impact business model feasibility (by increasing it wider accessibility and attractiveness to different user groups), and also the extent to which it is possible to scale up access to this part of the population.

In terms of behavioural interventions, initiatives that create client incentives (differentiated in terms of males and female needs) for take-up or increased usage of a product by making financing options and/or product attributes more attractive to the user, make good business sense and have broad applicability to businesses in varying fields.

In conjunction to this we will supplement the RCT with additional *interviews of stakeholders in the renewable lighting sector*. Our stakeholder engagements with other enterprises (e.g., Acumen, SolarAid, SunnyMoney, and Colibri) in the solar light industry active in Rwanda, and other developing countries, have been very fruitful. Through this exercise we have established agreements with at least two of these (SolarAid and Colibri) to *share empirical data from our research studies and to collaborate in comparing our findings related to financial, behavioural and gender-focused interventions and also assessing the generalisability or external validity of our findings*. By working in collaboration with other research being conducted in this field, we hope to bring to light a compelling body of evidence illustrating the welfare impacts (on particularly females and children) of scaling-up renewable technologies to the rural poor in the developing countries.

## 4 Background and Scoping Methodology

Nuru, a social enterprise in the renewable lighting industry, has been engaged in Rwanda for some time expanding its model for LED-lighting distribution (over 1200 village-level-microenterprises; it also has the largest market share in Rwanda (GVEP, 2012)). The research team has been working alongside Nuru to develop a proposal for evaluating different business models (with a specific focus on female empowerment and the impacts of this) and the impact of the distribution of LED-lighting and mobile phone charging in poor rural villages. While we have partnered with Nuru to do the largest quantitative part of this study, the women's empowerment and business models we are planning on testing are much more broadly applicable to other renewable lighting contexts and possibly to any business which distributes a product in a market aimed at the ultra-poor (females and children in particular).

One of the key features of the existing model for implementation through village level enterprises (VLEs) has been the skewed gender distribution of the VLEs (in favour of males) and preliminary empirical evidence from Nuru's existing database indicating that female VLEs have been more successful than male VLEs in selling LED lights in villages. With the support of ENERGIA funding, we have therefore been able to actively focus our proposed research and design to test specifically how changing the VLE gender composition may impact the Nuru-business model. We will also test how empowering female entrepreneurs in rural villages may have an impact on the overall wellbeing of households, with particular attention to the impact on female children in the households and villages with more active female VLE representation.

In preparing background material to inform our research design and process, our scoping phase has involved a multi-tier approach:

1. An extensive review of existing literature,
2. Exploratory interviews with stakeholder communities on the ground in rural Rwanda, iii) key informant interviews with gender experts at universities, in local and national government and at NGOs, as, well and interviews with stakeholders in the renewable lighting sector
3. Extensive engagement with Nuru Energy's CEO, including other co-founders and senior engineers, and Rwanda team to become familiar with the details of their operations, and to jointly plan for development and roll-out of the new gender empowerment business model

In parallel with this, we have also worked to develop and refine our research design, which we will test in an operational pilot in 2015. The researchers and IPA have:

4. Developed different business models to be evaluated,
5. Assembled baseline and endline surveys to measure treatment effects
6. Applied for Institutional Review Board (IRB) or ethics approval in Rwanda, with IPA and also with University of Cape Town,
7. Developed and will finalise contracts between all implementing partners prior roll-out and finalisation of the scoping phase.
8. Started a process of engagement with ENERGIA and the other teams involved with ENERGIA's bilateral programme.
9. Last and most important, we completed the rollout of multiple pilot studies in 13 villages, the core aim of the scoping phase. This action-research provides evidence on which to build the main studies

## 5 Review of the Evidence

### 5.1 Gender, Energy and Entrepreneurship

Globally, 1.3 billion individuals are without modern power; about 600 million of these are living in Africa, and that number is projected to grow as population growth outstrips grid expansion capabilities, rising to 700 million affected by 2030 (Lighting Africa, 2012). That energy poverty is related to income poverty is clear (Casillas and Kammen, 2010). Recent economic research has highlighted the positive role that the introduction of electricity, infrastructure, and technology in general, plays in important economic outcomes (Dinkelman, 2011; for long-term effects see Banerjee et al., 2015). Given poor households' large fuel expenditures (e.g. up to 40% of household income in rural Rwanda is spent on kerosene (UN, 2012) while in Malawi, lighting costs comprise 19% of household expenditure (Adkins et al., 2010)), the reductions in costs promise to have significant positive welfare impacts for the poorest of the poor (Berry, 2009; Adkins et al, 2010) and particularly also for women and children who are the most vulnerable in these rural poor communities.

Women and girls continue to have the highest demand for energy resources for activities within the household and yet, due to social, cultural, and traditional barriers, they are left out of that decision making process. Outside of the household, "women represent almost 40 percent of entrepreneurs in Africa. Yet, they are disproportionately represented among the self-employed and in the informal sector and among those operating smaller firms. As such, women are often earning lower returns on their time and investment than men" (Hallward Driemeie, 2011). A large number of programmes under a wide set of strategies have aimed at reducing existing inequalities by empowering women; in most cases, these programmes aim at economic empowerment, under the premise that economic empowerment will unleash empowerment in other dimensions.

According to Batliwala and Reddy (2003) a change of mind-set is necessary on the part of energy planners and activists to successfully empower women as energy entrepreneurs, as they must promote the notion of women as managers and entrepreneurs, and not just beneficiaries of improved energy service. To cement the effects of empowerment, it is crucial that the enterprises have some degree of financial success. Chaurey et al., (2012) analyses business models to enhance energy access at the bottom of the pyramid, identifies community ownership, capacity building and training as key factors in business success. However, it is important to keep in mind that even if the enterprises are not highly profitable, they may still have important effects on the entrepreneurs and their households as women's enterprises provide crucial sources of household income (Clancy and Dutta, 2005).

The scoping phase of the literature has yielded very important findings with regards to the role of females within the Rwandan system, both at national level and within the corporate and domestic spheres. While there are several programmes and initiatives aimed at uplifting and strengthening the role of women in society and in particular in the workplace, women's decision making power and general role within the household is still highly constrained, impacting on their economic activity, educational opportunities, time-use and general wellbeing (defined here more broadly to include material- and subjective-wellbeing e.g. economic, assets, employment, food expenditure and general expenditures, subjective wellbeing, life satisfaction, emotional wellbeing, self-reported physical health).

In Rwanda, the National Gender Policy (2010) states that, at a national level, women's participation in the workforce is about 56% (of the total female working age population), of which 55.8% have occupations and 87.6% participate in informal agricultural activities. Participation by women is higher (66.3%) in rural areas and in urban areas 53.5% women participate in the workforce. In urban areas, most women perform supporting roles and are not hired at top-level positions. Only 18% of well-structured companies are run by women, a large number of which are in the informal sector, generally comprising small businesses. Concerning access to employment, the majority of women are employed as unskilled labourers, traders or craftsmen. Of these, 14.8% women earn cash incomes, 15.7% earn incomes in cash or kind and 57% earn little or nothing.

Most of the available evidence on gender and entrepreneurship, is in the form of case studies. Although deeply insightful, these studies are based on very small samples and their results are difficult to generalise. Two interesting exceptions are provided by Kanagawa and Nakata (2007) and Sovacool (2013). Kanagawa and Nakata (2007) analyse socio-economic impacts of changes in stoves adopted by rural households in India, while Sovacool (2013) analyses a collection of eight case studies. Our study will similarly provide high quality, gender-disaggregated data on the relation between gender, entrepreneurship, and renewable energy.

## 5.2 Review of existing business models

Given the focus of our specific research project on optimization of business models aimed at adoption of clean technology, it is relevant to gain some understanding of how the energy market currently works in Sub-Saharan Africa, and which are the main business model trends that have arisen in response to these market conditions.

As previously noted, grid-based electrification favours higher-income communities, and when communities are electrified (even using low-cost micro-grids), low-income households frequently cannot afford the connection charges (Lee et al., 2015). There is emerging evidence of an 'energy ladder' whereby smaller lights pave the way for the emergence of pay-as-you-go and solar home system segments as markets grow. But even though cheaper rechargeable lighting technologies (e.g. bulbs which could be recharged using mechanical/solar energy) are available, their adoption is low and many consumers still use kerosene (IEA, 2014). As Wong (2012) states: "Financial exclusion is among the main obstacles that constrain poor people from obtaining solar lighting".

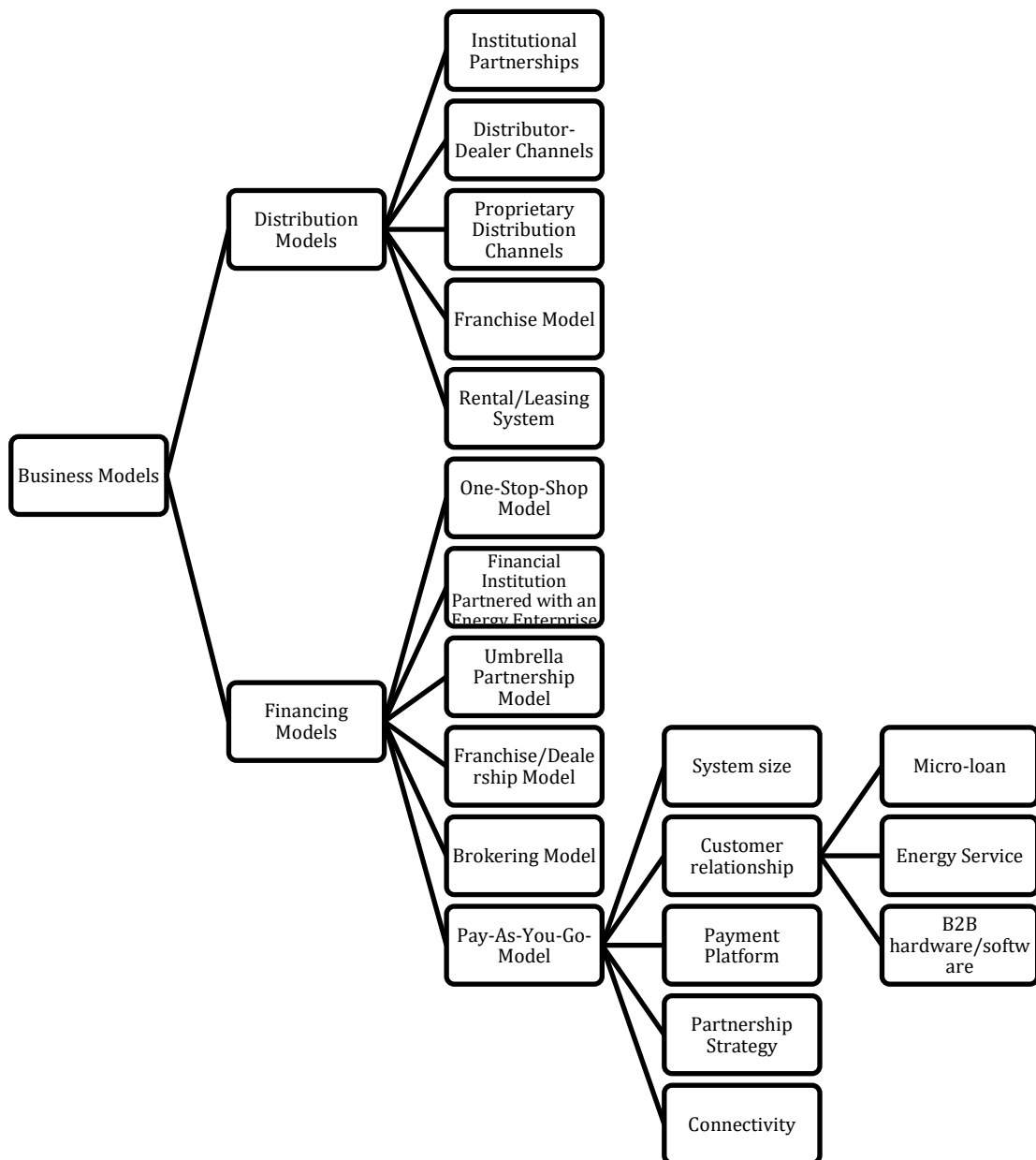
Specific examples from our overview of other business models (Section 3.4.1) in the renewable lighting industry has for instance indicated that with most renewable lighting products using pay-as-you-go (PAYG) financing mechanisms, households face upfront down payments of \$18-75, where after they are expected to pay weekly (or monthly) instalments ranging from \$2.73-\$5.24 per week (\$0.39-0.75 per day) over a period of 18 – 36 months. It is clear that barring the upfront payment which would already be very challenging for households living on \$1.25/day to come by, the down-payments itself would swallow up to half their daily income for a period of 1.5-3 years.

The importance of optimal pricing is further underscored by a study currently being executed by researchers from ETC-Zurich and IPA Kenya, in partnership with SunnyMoney at SolarAid. Preliminary results from their study in Kenya show that, even with significantly higher marketing and distribution costs, less than a third of households purchased just one solar lantern at the full price, whereas more than two-thirds did so when provided with subsidies .

### 5.3 Business Models

Traditionally the literature on micro-enterprise development has focused on a number of interventions such as micro-finance, business training, financial capital (cash grants), and more recently micro-savings and empowerment of female entrepreneurs, to help increase growth in micro-enterprises. However, there is very little evidence on what works and there is a great deal which needs to be understood (Karlan et al, 2012; McKenzie et al, 2012). Energy market dynamics have enabled the emergence of a vast series of innovative business models which could be classified into two groups: distribution and financing models (see Figure 3.1).

Figure 3.1: Business models



### 5.3.1 Distribution Models

The five distribution models identified to be prevalent by Scott et al., (2015) are as follows: institutional partnerships, distributor-dealer channels, proprietary distribution channels, franchise model, and the rental/leasing system. In some countries, distribution can account for up to 50% of the final product cost. By 2010, the vast majority of companies relied on the distributor/dealer (outsourcing to an in-country dealer) or proprietary distribution (i.e., direct-to-consumer) models (Lighting Africa, 2010).

Ultra-poor households (and particularly females in cash and credit poor households) who are accustomed to purchasing energy in small increments might find some energy services prohibitively expensive. For this reason, providers should design financing and payment schemes to help consumers purchase products that fit their energy budgets. The World Resources Institute (WRI) brought together the experiences of 25 socially oriented energy enterprises, organisations and financiers, and described the specific financing strategies to overcome the challenges previously mentioned. The six respective business models that focus on the financial sustainability of the provision of energy products are: one-stop-shop model, a financial institution partnered with an energy enterprise, the umbrella partnership model, the franchise/dealership model, the brokering model, and the pay-as-you-go model (Ballesteros et al, 2013). The main trend is the emergence of pay-as-you-go technology, which enables customers to pay over time, a development that has greatly facilitated uptake of technology amongst the poor. Given severe cash and credit constraints amongst the most marginalized rural communities (in particular women), PAYG systems therefore promises to dramatically increase accessibility of lighting to the poor.

Table 3.1: Pay-as-you-go systems

Company	Country	Product/Service	Payment	
			Platform	Schedule
<b>M-KOPA</b>	Kenya, Uganda, Tanzania	Solar kits: two bulbs, a phone-charging facility and a chargeable radio	Mobile money. Tanzania (M-Pesa), Uganda (MTN mobile money or Airtel Money).	- Down payment: Sh2,999 (\$29)  -Daily fee of Sh40 (\$0.39) over a period of 365 days (buyers own the solar kit once they are done paying)
<b>Mobisol kits</b>	Tanzania, Rwanda	Solar kits: 3-6 LED lights, lamp shades and switches, portable light, mobile phone chargers, a DC flat screen TV and decoder and a DC radio.	Mobile money.	-Down payment: Sh7,904 (\$75)  -36 monthly payments of Sh2,318 (\$22)

<b>One Acre Fund (grant-funded NGO)</b>	Kenya, Rwanda, Burundi, Tanzania, Uganda, Malawi	A range of solar kits for small-scale farmers	Mobile money and in-person meetings.	-Pre-payment + a little bit each week + the remaining at the end of the harvest: Sh1,899 (\$18) to Sh4,215 (\$40)
<b>Helvetic Solar</b>	Tanzania, Kenya, Rwanda, Burundi, Uganda, Nigeria, South Africa, Botswana and South Sudan	Solar kit: 6-8 LED lights and a phone charger.	Mobile money: Airtel Money, Tigo Pesa, M-Pesa, and Equity Bank.	-Down payment: Sh2,107 (\$20) -12 monthly payments of Sh1,053 (\$10).
<b>Azuri Technologies</b>	Tanzania, Kenya, Ethiopia, Uganda, Sierra Leone, Malawi, Zimbabwe, South Africa, Rwanda, Togo, and Ghana	Solar kits: lights and a mobile phone charging unit.	Mobile money: Kenya (M-Pesa) Tanzania (Tigo Pesa), Ghana (MTN Mobile Money) and M-Birr in Ethiopia.	-Down payment: Sh1,053 (\$10) deposit. -Weekly payments of between \$2.5 and \$3.5 for a period of 12 to 18 months.
<b>Nuru Energy</b>	Rwanda, Kenya, Uganda, Cameroon, India, potentially Bangladesh	Central Octopus Charger powered by solar panel and powercycle operated by village microenterprise. Light and mobile phone charging. LED lights.	Mobile money: Tigo MTN  Cash	Lights \$1.5.  Twice per month recharges of \$0.13

Source: Own elaboration based on Herbling (2015) information.

#### 5.4 Nuru's business model and comparative context

Nuru's distribution model falls under the **Rental/leasing system** mentioned above: The company franchises or contracts to micro-entrepreneurs (Village level Entrepreneurs) who set up charging kiosks, which work with the solar/human powered recharging "Octopus". These micro-entrepreneurs then sell rechargeable, LED lights (that provide around 20 hours of illumination per recharge) without a power source to the client, to reduce the upfront price of lights faced by customers. The entrepreneur offers recharges at a fixed fee.

The Nuru VLE remains the only source for recharging of the LED light by Nuru customers. This creates a sustained income generating activity through recharge for the micro-entrepreneur, for as long as there are Nuru light users in his/her village. This distribution model allows access to light for

customers who cannot afford the full cost of other renewable energy technologies by mimicking the incremental small purchases of kerosene or dry batteries which customers already use.

From a financial point of view, Nuru's model is also fairly unique; many models for solar panel customers involve payment schemes that immediately or eventually pay off the panel and have customers become the owners of the technology (though these are not comparable products being considerably more expensive). Nuru customers, however, will continue paying for recharging the lights through VLEs, without reaching ownership of the charging source (although they will be able to buy the same solar panel that the VLE uses for recharging, if they can afford it). The micro-entrepreneurs', however, achieve full ownership of the solar panel and recharge facility, once this has been paid off via the above revenue.

Nuru lights, are specifically designed to be entry-level lights to households who can't afford alternative sources of clean lighting, like solar lamps. Moreover, ultra-affordable micropayments for recharges help consumers to combat their liquidity constraints. Nuru LED lights costs around \$0.13 per recharge (every 10-14 days) while the VLE recuperates the cost of the equipment, and then drops to half that price, once the equipment has been paid off and now owned by village entrepreneurs. This in comparison with weekly down-payments (PAYG) for many solar products which as mentioned earlier can be up to half the daily income over a period of 1.5-3 years for a household living on \$1.25/day.

Nuru's financing model for recharges by end-users functions by selling the hours of light instead of selling the recharge equipment. It therefore resembles the pay-per-use service provided by grid-connections (cash-power). The act of visiting the recharge centre to purchase light resembles the act of purchasing light (kerosene, candles, torches, paying for grid electricity) from a shopkeeper. This may be an advantage as it is observed that although often economically inconvenient, customers are reluctant to modify habits away from current practices due to, among other causes, status-quo behavioural bias.

The model does however fall under the Pay-As-You-Go (PAYG) umbrella, providing an amount of lighting energy in exchange for ongoing payments. Although in this case, the payments are not going towards the acquisition of the recharge technology, as PAYG schemes used by Mobisol, M-Kopa, Helvetic Solar and Azuri Technologies do (see table 3.1), but rather the recharge of already owned light sources (e.g. customers own the lights, they just don't own the recharge station which is owned by the microenterprise). As such, this model minimizes transaction costs and has the dynamism required to fit the technology and financial circumstances of ultra-poor consumers. It also accommodates increments at times preferred by consumers, who are able to recharge according to their liquidity (no fixed payment plans).

There has been recognition of the crucial role of women in energy and lighting use, as well as, improved achievements as micro-entrepreneurs and more pro-social management of income. These qualities and efforts for empowerment have been pushing for some gender-focused initiatives in solar lighting distribution. Solar Sister and Kopernik's WonderWomen solar light distribution programmes specifically recruit women as micro-entrepreneurs to distribute their technologies. While qualitative results from these initiatives indicates positive impacts, there is very little rigorous evaluations that has assessed these gender specific impacts. Although Nuru's VLEs have predominantly comprised male groupings with females taking a backseat in enterprise development, a main aim of this study is to rigorously test the impact of empowering women by varying the



proportion of females amongst VLEs and testing the impacts of that on both the females and their families.

## 5.5 Stakeholder engagement

Through a series of interviews with various development professionals operating in African and Latin American countries, we gathered information about six solar energy distribution programmes carried out by non-profits (SolarAid, Kopernik), social businesses (SunnyMoney, Solar Sister, Colibrí, Great Lakes Energy, Waka Waka) or by a partnership of several national development agencies (EnDev). Kopernik's "Wonder Women Indonesia" program and Solar Sister distribute their products mostly through micro-franchises. They explicitly aim at economically empowering women by helping them to become successful business-owners. Colibrí and Waka Waka distribute their products through a mix of direct sales and micro-franchises. Despite including a strong gender-sensitivity component in their approach, they accept both men and women as retailers. The other two programmes operate at different levels: Great lakes Energy used to sell solar lanterns on consignment to existing stores without much success and shifted to direct sales of larger solar systems to health infrastructure. EnDev manages a result-based financing program open to any Lighting Africa certified solar lanterns importer in Rwanda.

Here we discuss each of these stakeholders in terms of their gender focus, focus on the poorest sector in the market and in terms of the financing solutions (for retailers and end-users).

### 5.5.1 Gender focus

#### 5.5.1.1 Marketing towards women:

If the focus on gender varies a lot across programmes, women are widely recognized as being the ones usually using and managing energy within the household. They make energy-related purchases (kerosene, candles). They are more exposed to health hazards related to indoor use of unclean energy sources (burns, respiratory illnesses, eye irritations). Thus they are in a position to better understand the potential advantages of switching to clean energy. They are also credited to make more productive and family-oriented energy decisions. "The family's father wanted the lights in his office, bedroom, and main room. But his wife successfully argued instead for a light in the room where she cooked dinner, a light outside for security, and a light for her chicken coop. After all, chickens lay more eggs when they have more light."<sup>1</sup> Women and girls are reported to use light for safety purposes when walking around after dark (e.g. coming back from school or going to the latrine for example). For these reasons, they are well identified as potential customers. Even in projects without a specific focus on gender issues, stakeholders reckon solar energy companies should focus on women as potential customers, because it makes good business sense, and because clean energy distribution has a larger impact on households when women are better included in the process. This is also central to the current evaluation Nuru has embarked on by providing more than one light per household and focussing on behavioural interventions that will improve ease of recharging for women in particular.

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<sup>1</sup> <https://www.solarsister.org/blog/low-cost-solar-brightens-lives-in-the-developing-world>

### 5.5.1.2 Women as successful clean energy sellers:

Kopernik (through the “Wonder Women Indonesia program”) and Solar Sister (operating in Uganda, Tanzania and Sudan) target women not only as clean energy customers but also as key distribution actors. They aim at economically empowering women and increasing their self-confidence by providing them with the skills and the inventory to start their own business retailing clean energy products (e.g. solar lights, clean stoves, water filters). In the case of Kopernik, the program was not gender-oriented when it started, but as more and more women spontaneously enrolled to be retailers in the “tech kiosk program”, Kopernik turned it into the “Wonder Women Indonesia program” and started to target women specifically. Interestingly, women self-selected into the program, which support the claim that women feel competent dealing with energy. Solar Sister shares this statement, but insists on the need for training in general business skills (accountancy, money management, planning). Both organizations stress the fact that they target women not only to empower them, but also because they are good at selling clean energy products. Because of their good understanding of the benefits of clean energy and because they can take advantage of existing women networks to distribute their products, a “women-to-women” distribution chain works particularly well.

Waka Waka is a low-cost solar lanterns distributor operating in Rwanda (amongst other countries). Waka Waka states that female staff tend to be better communicators and to give more valuable input identifying customers’ needs whereas male staff tends to be better at delivering the product. Working under the assumption that men and women have different strengths, they create different types of partnerships with men and women: about 90% of their dealers are male, whereas about 90% of the cooperatives they partner up with are women cooperatives. Dealers are existing businesses (e.g. shops or kiosks) whereas cooperatives are associations or networks of individuals getting together for a specific purpose (e.g. improving children’s studying conditions, improving safety at night for women, etc.) and organizing various meeting and events towards that common goal. Dealers sell solar lanterns to make a margin on it, whereas cooperatives sell solar lanterns to their members in order to reach a shared purpose together; these two approaches of distribution obviously involve different perspectives and different types of skills. Cooperative is reported to be a successful model.

### 5.5.1.3 Different strategies to overcome gender specific barriers:

Colibrí is a young social business operating in Nicaragua, distributing solar lanterns and solar home systems through a network of existing *pulperías* (small “mom-and-pop” shops) and sometimes through community leaders (schoolteachers, priests). So far, out of 49 points of sale, 17 are female-owned or female-managed. Despite having females in these leading roles within the organization, Colibrí has found that, oftentimes, women will not make any business/purchase decisions when their husband is not available for input. Although Colibrí does not specifically focus on enrolling women as retailers, they stress the importance of gender-sensitivity in their operations (mostly through partnering with a gender-oriented MFI and through recruitment and training of staff) in a general context of “rampant sexism”.

As for the programmes specifically encouraging women to create their business, there are different approaches on how to work around prevailing gender norms. For example, Kopernik hires male staff for technical tasks whereas Solar Sister trains the female entrepreneurs to perform these tasks, even if they involve actions that women do not normally do (e.g. climbing on roofs to install home solar systems). Kopernik encourages collective family decisions: women interested in being part of the

program are invited to get the agreement of their family (spouse and children) before applying. More generally, Kopernik tends to learn about local cultural context, to acknowledge the constraints faced by women (usually they cannot travel overnight or be away from their family for too long) and to work around them, whereas Solar Sister insists on the importance on coaching the female entrepreneurs to change prevailing norms.

### 5.5.2 Focus on the poor

The focus on the poor varies across projects. Waka Waka started with a strong focus on poor customers, but as investors from developed countries showed interest, the company shifted to a for-profit model – but has kept a strong focus on base-of-the-pyramid customers. Solar Sister, Kopernik and Colibrí target people living at “the last mile”, who are likely to be income poor. In the case of EnDev's result-based financing program, companies applying to the program are expected to target the poor living in rural areas, but they also sell to richer segments. EnDev does not monitor operations: the program aims at accelerating the development of the solar energy market by giving companies financial incentives to import larger quantities. Any company importing Lighting Africa certified solar lights and selling them with a warranty is eligible to the program. This is particularly important: EnDev values diversity of business models and competition between companies. The poor are regarded as customers who know what they need and hence who should have the choice of the product they buy.

#### 5.5.2.1 Building the brand:

The renewable energy companies engaged have stressed the importance of building their brand and establishing a reputation of quality and reliability. Several of them mentioned cases of companies selling low-quality or faulty solar lanterns and not providing any after-sale service, creating a mistrust towards solar lanterns amongst customers. In all the programmes surveyed, the products come with a warranty from 1 to 3 years.

Colibrí and Waka Waka try to move away from the traditional image of energy companies and to market solar lanterns as if they were fast-moving consumer goods.

#### 5.5.2.2 Importance of ownership:

Colibrí and Waka Waka both propose lease-to-own models. Colibrí customers tend to find larger systems more attractive than smaller, portable device (although Colibrí's best-sellers are low-cost portable devices not home systems), which means that customers see solar system purchase as an investment that might as well be maximized. Providing customers with a product they own (either right from the start, or through a lease-to-own model) also gives a comparative advantage to companies “racing with the grid”: solar systems provide electricity for free once they are paid off, whereas electricity bills need to be paid on a regular basis for ever. If leasing does not appeal to customers, investors tend to like it because it ensures a regular revenue stream. Colibrí is considering a model where consumers, after paying-off their solar system, have the option to get consistent consumer service for a small (under 1USD) monthly fee.

### 5.5.3 Financing solutions

#### 5.5.3.1 Financing solutions for retailers:

Micro-consignment is being used successfully by Kopernik and Colibrí. In both cases, retailers get the inventory for free and pay back after selling to end-users. Retailers have the option of paying upfront to make a higher margin. Solar Sister used to do micro-consignment but stopped using it because of low repayment rate. Now, they provide micro-entrepreneurs with a “business-in-a-bag”. Equipment, training and marketing material are given for free, but retailers need to buy the inventory upfront (approx. 500 USD). Solar Sister partners up with local SACCO agencies so that micro-entrepreneur can get a loan to finance this initial investment.

Great Lakes Energy also stopped selling on consignment to shops, because shopkeepers did not put particular efforts into selling solar lanterns due to lack of incentives.

#### 5.5.3.2 Financing solutions for end-users:

A common difficulty when distributing solar energy products in rural areas is that end-users tend to have seasonal variations in their income, due to harvest seasons. Colibrí found that retailers prefer using informal credit over pay-as-you-go models when selling solar lighting devices worth up to 150 USD. They are used to work give informal credit to their customers and find it more convenient to be paid in two instalments than dealing with activation codes or remote-locking mechanisms. Colibrí is about to start distributing a larger, more expensive model (190 USD). At this price, customers will not be able to pay in two instalments, and a pay-as-you go model becomes a relevant choice, although it increases unit.

Table 3.2 Prices of different stakeholder products in USD

	Solar lantern (without phone charger)	Solar lantern (with phone charger)	Solar home system	Phone charger
<b>EnDev</b>	--	20 to 100		--
<b>Kopernik</b>	10 to 20	40	100	--
<b>Solar Sister</b>	10			10 to 20
<b>Colibrí</b>	--	40	150 to 190	--
<b>Waka Waka</b>	--	35 (45 if pay-as-you-go model)	--	--
<b>Nuru Energy</b>	1.5 charges 0.13 every 2 weeks. Phone charging also			
<b>SolarAid</b>	10			

Waka Waka also sells to consumers earning a variable income. Their lease-to-own model does not include a fixed instalment schedule: customers can choose when they do payments. Their system is remotely locked until it is fully paid for. They can unlock it by buying an activation code allowing them to use their solar system for a week. When the system is paid for, it is permanently unlocked.

## 5.6 Preliminary results from pilot data

Preliminary results from an ongoing RCT (in partnership with SolarAid and SunnyMoney) in Kenya on low-cost solar-lanterns (using Greenlight Planet and d-light products) which also provide reduced-price vouchers, show that even with significant marketing and distribution costs, less than a third of households purchased just one solar lantern at the full price, whereas more than two-thirds did when provided with subsidies. Importantly these lanterns are the most basic entry-level lanterns which do not provide mobile phone charging, a service available in our main partner's low-cost light model.

***Our initial pilot results echo these finding above:*** We find that demand for light drops dramatically as the upfront price increases.

***Preliminary gender entrepreneurship piloting results yielded the following evidence:*** Gender randomisation and the formation of micro-enterprises happened rapidly and smoothly. Expected barriers including traditional male authority structures and the possibility women would struggle to raise the pre-order commitment fee (\$10 each) failed to materialise.

A total of 20 *potential microenterprise groups* were formed all according to the randomly pre-assigned gender composition, with 11 groups formally becoming microenterprises and the remaining serving as the comparison group. These groups were surveyed in a baseline survey in order to answer our primary research questions outlined above, and will be surveyed again in the endline survey in order to determine the impact of the **empowerment programme**.

## 5.7 Lessons Learned from Scoping Phase and Process

We have gained many insights from the business model overview we conducted as part of the revisions for the Scoping Report. This has helped us to contextualize Nuru's business model but also the generalisability of the research questions we are investigating in a much wider context. Having learnt the importance of designing sustainable financial interventions to facilitate take-up and use amongst the ultra-poor and also the role of behavioural interventions related to convenience, we feel more convinced than ever that the research we are undertaking is crucially important in facilitating adoption and use of new renewable technologies.

In line with the points raised above, several of the interviews we conducted with stakeholders in the solar lighting industry indicated that pricing of products is a significant barrier to uptake and that more research investigating financial models should be an imperative. Our interactions with these stakeholders have also been extremely productive in making connections and initialising possible collaborations which will allow us to draw comparisons across different business models. The research team is grateful to the ENERGIA Steering Committee for their recommendation to include this, and we give thanks in particular to Soma Dutta from the TAG team for linking us to some of the stakeholders with whom we have engaged.

In terms of lessons learnt on the ground we feel we have gained a better understanding of gender issues when implementing the RCT. We have also engaged with numerous technical challenges in team interfacing and support and learnt more in terms of interfacing with Nuru and dealing with technical delays and challenges. Specifically a lot of our attention has been devoted to problems with data capturing and prevention of spillovers. Having conducted the initial roll-out of the pilot have also shed light on many of these issues and enabled us to correct problems as they arise.

## 6 PROPOSAL FOR PHASE 2

### 6.1 Framework for rolling out several large-scale RCTs: Research implementation

Our methodological framework comprises a very strong quantitative component in that it uses a series of Randomised Control Field Trials (RCTs) to rigorously assess the impact of the financial, business and gender interventions we are planning to roll out. In as far as possible we try to complement this with comparative empirical data from other stakeholders in the solar industry and/or qualitative methods to inform our design, implementation and also inference of results. A summary of the research implementation steps is given below.

**Piloting of the project** began in late November 2015 and concludes in April 2016. The pilot takes place in 13 villages and 20 potential microenterprise groups. After analysing interventions tested in the pilot, we will commence with the full-scale study.

**First**, phase II will begin with baseline surveys in **over 200** villages. We intend to complete our baseline study in 2016, **and are on track to do so**.

**Second**, after completion of the baseline surveys, the sample of villages will be randomly split into **treatment and control villages**: half will receive equipment and training to become Nuru microenterprises, while the other half will serve as the control group.

**Third**, the gender composition of micro-enterprises will be randomly assigned to different villages linked to 3 treatments: 1. Female only 2. Female-male (50-50 split) 3. Male only. Microenterprises will be set-up, entrepreneurs self-selected and trained and equipment distributed. There are a total of 3 gender composition village-level interventions to be tested.

**Fourth**, we will randomly *assign the best-performing business model interventions* as determined from analysis of the phase I results. (That is from the set of all interventions tested in the piloting phase, the most successful will be rolled out in the main study.)

**Fifth**, endline surveys in over 200 villages will begin in 2017. **This completes phase II**

**Finally, phase III** begins as Nuru expands to more villages which is beyond this scoping report (*timeline, as well as exact number of villages determined after phase II is completed*).

In conjunction to this we will supplement the RCT with additional interviews of stakeholders in the renewable lighting sector. Our stakeholder engagements with other enterprises (e.g., Acumen, SolarAid, SunnyMoney, and Colibri) in the solar light industry active in Rwanda, and other developing countries, have been very fruitful. Through this exercise we have established agreements with at least two of these (SolarAid and Colibri) to share empirical data from our research studies and to collaborate in comparing our findings related to financial, behavioural and gender-focussed interventions and also assessing the generalisability or external validity of our findings.

Further, it is important to note that many of our RCTs will follow the new and innovative methods of faster-paced, trial-and-error, and smaller-scale mechanism and business experiments to speed up results, reduce costs, and uncover the underlying causal mechanisms often unobserved by the 'black-box' nature of large randomised policy evaluations (Deaton, 2010; Manzi, 2012; Harford, 2012; Ludwig et al., 2012).

## 6.2 Motivating use of RCTs & strategies for dealing with weaknesses

Since randomisation is the optimal design for avoiding study bias, and given our research team's main focus on causal questions, the choice of methodology follows naturally. Our project, therefore, uses a series of large-scale longitudinal randomised field experiments – informed by practice, relevant literature, qualitative findings, theoretical modelling, and extensive piloting – to establish results policymakers can treat with a significant degree of confidence. High-quality individual RCTs provide solid unbiased building blocks to synthesize a body of evidence using meta-analyses, systematic reviews, and comparative analyses.

When correctly implemented and compared to other quantitative methods, such techniques, allow the most credible answer to the counterfactual question—or what would have occurred in the absence of an intervention (Glewwe et al, 2004; Arceneaux, Gerber, & Green, 2006; Angrist and Pischke, 2010; Imbens, 2010, DFID, 2014). Randomisation solves the counterfactual problem by creating a comparison group that is, in large enough samples, identical to the treatment group on both observable or measurable and unobservable or unmeasurable characteristics thus eliminating bias (Takavarasha & Glennerster, 2013).

Policymakers beyond health, where RCTs are well-established, hold similar positions. For instance, the UK Department for International Development's guide on assessing evidence argues there is no one-size-fits-all research design (DFID, 2014: p2). We strongly agree with this position, which is why our research project includes multiple RCTs, but extends beyond traditional experimental methodologies, and includes qualitative research. DFID also notes experimental “designs are useful for demonstrating the presence, and size of causal linkages (e.g. “a causes b”) with a high degree of confidence.” Furthermore, it judges “the overall ‘strength’ of a body of evidence by the quality (or “avoidance of bias”) of [individual] studies that constitute it, and by the size, context and consistency of this body of evidence” (DFID, 2014: p6).

However given the still many weaknesses of large randomised policy evaluations, we do not limit ourselves to the standard methods used in the plethora of randomised evaluations sweeping development and the social sciences. We elaborate on this below:

To further strengthen the generalizability generalisability of our findings, the experiments we employ are very large (e.g., generating data on tens of thousands of households and from hundreds of villages), include the statistical analysis of rich qualitative data, and cover more than one location and country. At this time, the most likely countries we expect to carry out smaller-scale quantitative research partnering with Nuru include Cameroon, where the Rwanda model will be extended, as well as Bangladesh. In Bangladesh Nuru is potentially partnering with JITA a very large social business that has set up almost 8000 female entrepreneurs. JITA is a Care Social Business and won the 2014 UN Gender Equality Award.

However the largest of our studies, with our main partner Nuru Energy, will be conducted in multiple regions of Rwanda and in over 200 off-grid villages affecting hundreds of thousands of people. This is primarily because, of all social enterprises, Nuru Energy has been the most willing to allow researchers a very high degree of access and control which is essential in enabling research teams to implement large-scale controlled experiments. Nuru has also received guaranteed funding from the Diesel/OTB Foundation, Finland's government, and others, to roll out their program to 800 new villages in rural Rwanda: many of these were set up in the scoping phase, and the remaining



villages will be rolled out and studied in phase II of our project. This provides a unique opportunity to undertake multiple large-scale RCTs across rural Rwanda.

Furthermore, an important new strategy for RA5, our greater project will now also collaborate with other research teams to conduct a comparative analysis by combining datasets from similar RCTs – using similar methods and solar technologies but in yet more countries and contexts – in order to arrive at a higher overall quality body of evidence. This includes RA5 potentially conducting smaller-scale business experiments and a gender entrepreneurship RCT in Nicaragua partnering with Colibri a social enterprise which provides last mile distribution of Greenlight Planet solar lanterns (\$40) and home-solar systems through an agent-entrepreneur-based model similar to Nuru, SolarAid-SunnyMoney, and Solar Sister.

### 6.3 Strategy for empowering rural women

While our research questions and design is specifically tailored to uncover different aspects of gender empowerment at both the household and entrepreneur level, our research team does not contain any gender experts as such. We have been in constant communication with Energia and TAG team about how to strengthen this aspect of our research capacity and how to make use of the TAG team members in a greater capacity.

Dr Adelene Africa from the Gender Department at UCT, Gender Studies Department has expressed interest in the project and agreed to come on board in a capacity as gender expert – to work alongside the team in providing inputs with a strong gender focus. Going forwards we will ask Dr Africa (CV attached) to workshop our research questions and design to deepen our understanding of how the gender focused component of our research can be improved.

We have also approached other relevant organizations and institutions in Rwanda to solicit their insights and experiences working in the field of gender, energy, and entrepreneurship, and to learn more about the challenges that exist in implementing such programmes. Amongst these are: University of Rwanda's Centre for Gender Studies (CGS); government organizations such as MIGEPROF (Ministry of Gender and Family Promotion); a local chapter of an international organization, The Women's Bakery, and RWAMREC (Rwandan Men's Resource Centre).

### 6.4 Dissemination of research and timeline

Given the cross-cutting themes and levels at which the project is being implemented, there are multiple layers of stakeholders involved. In our report, we outline our specific plans for dissemination of the research and findings of this project with each of the relevant groups.

Using a planned workshop as a platform, we plan to open up many of the conversations initiated during the scoping phase to a wider audience that convenes private sector actors, and other players in the energy sector with relevant policy makers, as well, to demonstrate how the research can support the private sectors' push for collaboration with local government to reach Rwanda's 2020 goals of universal access to energy.

Likewise, we will continue to engage with stakeholders at the community level through introductory meetings with sector, and village leaders in the areas selected for study. Previous meetings for the piloting phase were conducted, in partnership with Nuru, and we plan to continue with that level of engagement for the villages involved in the main study.

While these represent the formal ways in which we plan to share our findings, we hope to maintain active communication with our developed networks for the duration of the study.

Using the findings from the literature review, stakeholder engagement, and pilot detailed in this scoping report, the main research will launch with the baseline study in July/August 2016. Leading up to the launch of the baseline, we also plan to deliver a policy article and stakeholder workshop (October), and a peer reviewed article (December) - borrowing from both this scoping phase, and the project pilot.

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