KTF

VILLAGE CONNECT

Solar Lighting & Energy Support for Remote Villages in Oro & Central Provinces, PNG

Table of Contents

Introduction

Energy poverty is the lack of access to modern energy services; it especially affects people in developing countries whose wellbeing is negatively affected by very low consumption of energy, use of dirty or polluting fuels, and excessive time spent collecting fuel to meet basic needs. Energy poverty impacts a significant proportion of the world's population. According to the UN's Tracking SDG 7 report, 840 million people still lack access to clean, reliable and affordable electricity. Most of these people live in rural areas in developing countries or belong to the urban poor.

KTF's Village Connect project was the first stage of the NGO's increased investment in supporting communities with improved access to clean energy and lighting in remote and rural PNG. Village Connect aims to connect remote villages to improved solar lighting and energy solutions, providing a cost effective and environmentally friendly source of lighting and energy. Target communities were selected on the basis of having a student enrolled at KTF's secondary and tertiary education facility, the Kokoda College. Due to the introduction of tablet-based learning at the Kokoda College, students require a lighting and energy source during their self-directed study periods in their home communities. Coupled with the fact that students are targeted based on remoteness, community need for teachers and health workers, and low development contexts, most of the communities have very limited access to energy solutions.

KTF's Village Connect project connected 1,000+ households and facilities to solar solutions between 2018 - 2020. This paper examines the impact of the project on a range of outcomes for families and communities. It examines the impact on education outcomes including time spent on homework and reading, the reduction of expenditure for families on kerosene, batteries and other forms of fuel, and the impact on perceived productivity, safety and security, and financial outcomes.

Data was collected in November - December 2020 from household members who had received their solar systems between 12 and 18 months prior.

Background

Energy poverty in a community affects physical health, wellbeing, safety and the ability to prosper (Njiru & Letema, 2018). The Global Network on Energy for Sustainable Development (GNESD) states that the majority of the world's poor live in rural areas with limited access to modern energy services and thus depend on traditional energy sources, e.g., biomass. Those who rely on traditional fuels, such as firewood, must spend several hours each day collecting fuels. This burden falls disproportionately to women and children, and it robs them of education and income-generating work (Nathwani, 2018).

The SDGs call for renewable energy sources to be the key technology to reach the energy poor, offering clean electricity, heating, cooking and lighting solutions to people and communities who currently depend on traditional energy sources and/or expensive fossil fuels. Renewables are regarded as desirable because they can provide small-scale solutions and decentralized energy supply to meets the needs of the population most widely affected by energy poverty. Innovations and cost reductions over the past decade mean that renewable energies are now more economically competitive than traditional fuels (Terrapon-Pfaff, Dienst, Konig & Ortiz, 2014). Off-grid solar products will save people money, supply brighter light for longer periods, create opportunities to generate income, and have a positive impact on health, education, gender equality, the environment, and quality of life.

PNG Context

Despite the incredible wealth of PNG in terms of its natural resources (containing 7% of the world's biodiversity), 40% of PNG's population is living below the poverty line, with 80% of the entire population (6.3 million of 8 million) without access to electricity. PNG is rated very low on the United Nations Human Development Index and World Bank's Human Capital Index.

According to a 2018 report by the International Finance Corporation (IFC), PNG has demonstrated remarkable uptake of off-grid solar technology over the past 6 years. 60% of households in PNG are now using some form of off-grid solar technology including off-grid solar lighting products and battery-based torches and lanterns, which have effectively reduced reliance on kerosene lamps1. According to the study: "Six years ago, only two percent of the population used any type of solar product and relied on firewood, kerosene and other products, harmful to people and the environment. It was a time when cellphone penetration was growing rapidly, but the means to charge those phones was lagging. Now kerosene has been usurped, and there's a prevalence of generic offerings, battery powered torches and lanterns, alongside quality-verified off-grid solar products – many with an ability to charge a phone."

However, despite these encouraging improvements in accessibility, many challenges continue to face PNG communities based in very remote regions across one of the most geographically diverse countries on the planet. Some regions across PNG face extremely low development outlooks particularly due to the challenges typically associated with remote and rugged locations, such as limited connectivity to telecommunications, and lack of essential service delivery including health and education. "Over 80 percent of people live in rural areas, yet with only 18 people per square kilometre, Papua New Guinea is one of the least densely populated countries in the world. Its steep mountains which stretch across the main island, with elevations of over 4000 meters, adds another layer of complexity to infrastructure and business development." (IFC, 2018)

A recent study on the impact of solar in PNG outlined the key barriers to energy access in PNG (Rawali et al., 2000). These relate to governance, lack of capacity, rugged terrain and sparsely distributed population, lack of finance and law and order issues. For example, in the IFC report it was found that there are no suppliers readily available to the majority of last-mile communities and mid-mile settings are also limited in access. This may be due to the population being sparsely scattered throughout the rural rugged terrain, further increasing the technical difficulty of extending electricity services and consequently the cost (Asia Pacific Energy Research Centre, 2017).

Furthermore, with the largest percentage of the population relying on subsistence farming as their main source of livelihood, access to finance also limits people's ability to acquire solar solutions especially in remote and rural locations where opportunities for formal employment are almost non-existent. This is in line with findings from a review by Chaurey, Krithika, Palit, Rakesh, and Sovacool (2012) which found that any community level energy access programs that require a monthly payment system are largely impractical and ineffective when people do not have consistent, reliable monthly incomes due to subsistence farming livelihoods.

In terms of the lack of governance, in a study by Sovacool (2011) it was found that governing entities had limited capacity to collect data on resources, supply and demand and coordinate between various government-agencies on energy matters, resulting in limited and stagnant developments in improving energy access. These are only a few examples of the challenges facing energy developments for remote communities in PNG.

Another example of one of the challenges facing energy access developments in PNG are the issues regarding law and order across many of the communities. These issues generally relate to theft, wilful damage and in some cases even armed hold ups, resulting in increased costs for security and ultimately a higher cost of off- grid systems (Engelmeier & Gaihre, 2019).

Yet there is hope; Rawali and colleagues (2020) concluded that solar household systems have a huge potential and can assist PNG to drive its electrification agenda (70% by 2030), but there is a need for complex pathways to be worked out amongst leading agencies to create a solution that overcomes the immense challenges for PNG. In order for such developments to be successful, appropriate policy and regulatory support is needed, as well as achievable financing mechanisms, and a major focus on partner and community capacity development including training, education, maintenance, and ongoing business opportunities.

Distribution Strategy

KTF's Village Connect project aims to improve remote and rural communities' access to energy, connectivity and lighting by installing household based solar systems one community at a time. The Village Connect distribution and installation approach between 2018 - 2020 was undertaken in line with KTF's other education development activities via a cluster approach and existing project supply chains.

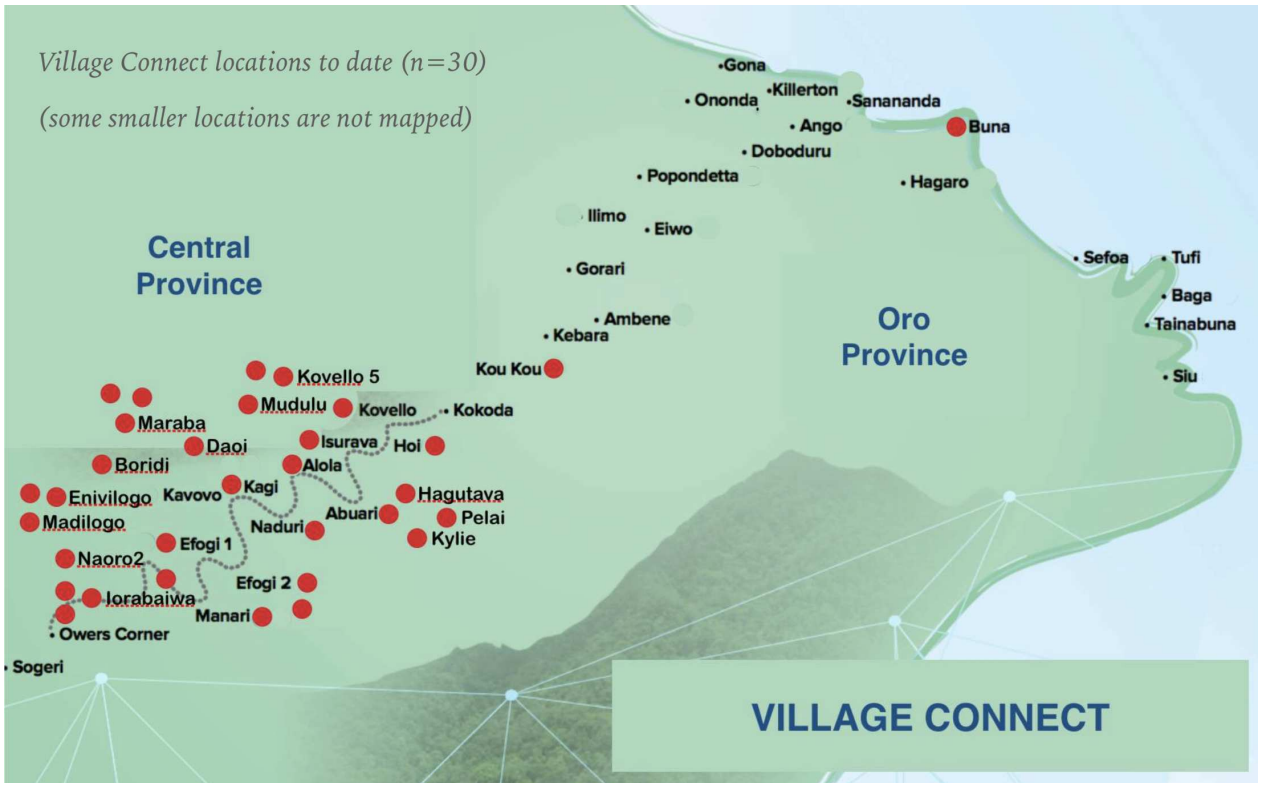
KTF's initial Phase 1 focus for Village Connect was for all villages located along the Kokoda Track to receive the systems. In Phase 2, the focus was expanded to the immediate catchment region.

There are numerous links to other KTF development projects:

➤ In 2019, KTF commenced tablet-based learning at its Kokoda College facility which delivers the Flexible Open Distance Education program in partnership with the Oro Provincial FODE office and National Department of Education. This was the first tablet-based FODE centre in the country and in 2019, KTF enrolled 125 students into the College program. These students require power solutions at home in order to continue their self-directed learning between face-to-face classes at the College. Phase 2 and 3 of the Village Connect project are particularly focused on lighting up the villages of the students enrolled at the Kokoda College.

➤ KTF's PNG Schools and Healthy Communities projects support the operations of elementary and primary schools and aid posts and health centres across the Kokoda Track catchment region. KTF's support to date includes training and postings of teachers and community health workers, infrastructure support, and regular resourcing. These schools and health facilities benefit from solar lighting and energy solutions for improved service delivery; and communication between KTF and its teachers and health workers is improved with access to lighting and power.

We also worked closely with a number of our co-delivery partners including the Kokoda Initiative (Department of Foreign Affairs and Trade) and No Roads to Health (NGO) to determine which areas should be focus areas for the project in order to enhance our collective development aims across the region.



Aims & Methodology

This research evaluation was commissioned by KTF to measure the impact of the household solar lighting and energy systems on a selection of outcomes for a sample of participants who have had systems installed onto their homes during the course of the Village Connect project.

A mixed-method approach was adopted including the administration of a short survey to a sample of household owners across the catchment region. Semi-structured interviews were also conducted with a sample of participants across the region.

The survey collected demographic data on the households as well as a series of questions to elucidate the impact of the solar lighting and energy systems on student study time, family kerosene usage, family income and other measures of wellbeing.

The survey was self-report and participants were encouraged to discuss their answers in small groups within each household. Survey delivery was facilitated via translators and interpreters to ensure respondent comprehension of all questions.

Semi-structured interviews with household owners and dwellers sought to further elucidate the survey answers and provide additional context to the quantitative data.

Surveys and interviews were undertake over a 5-week time period via KTF's in-country personnel. Participants in the evaluation had received their solar lighting and energy systems sometime between 12 and 18 months prior.

In total, 248 people participated in the survey including 63% male participants and 37% female participants.

Additionally, 169 people participated in semi structured interviews and/or focus groups. The breakdown of these participants include 54% males and 46 % females.

Villages that participated in the research evaluation included Alola, Abuari, Isurava, Kovello 1, Kovello 2, Hoi, Kou Kou and Kokoda.

Quantitative Findings

The 248 research participants represented 11 villages across the catchment region that had received the solar lighting and energy systems. The breakdown of the communities that participated in the research is:

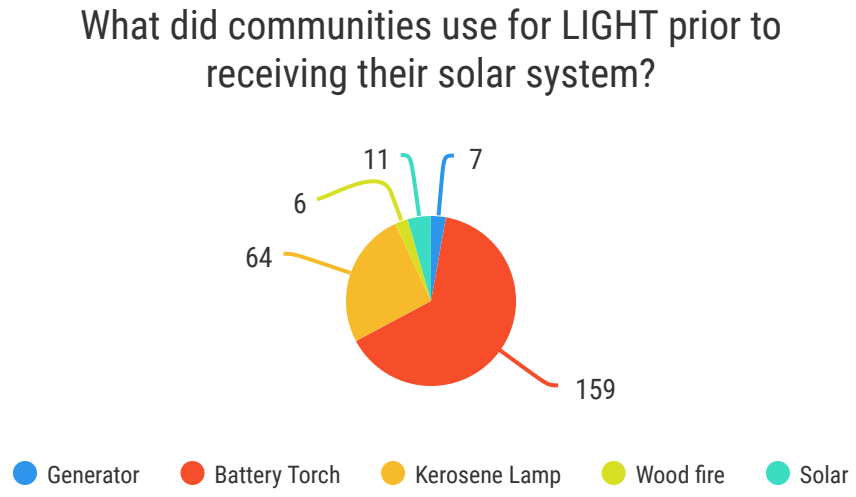
- 6 community members from Alola Village
- 4 community members from Isurava Battlefield Village
- 44 community members from Buna 1 Village
- 40 community members from Buna 2 Village
- 8 community members from Kokoda Village
- 24 community members from Hoi Village
- 20 community members from Isurava Village
- 7 community members from Kou Kou Village
- 83 community members from Kovello Village
- 12 community members from Mudulu Village
- 1 community members from Soga Village

Survey participants ranged in age from 19 to 81 years of age; with the average age being 40 years.

The average number of people per household across the region was 6 per household:

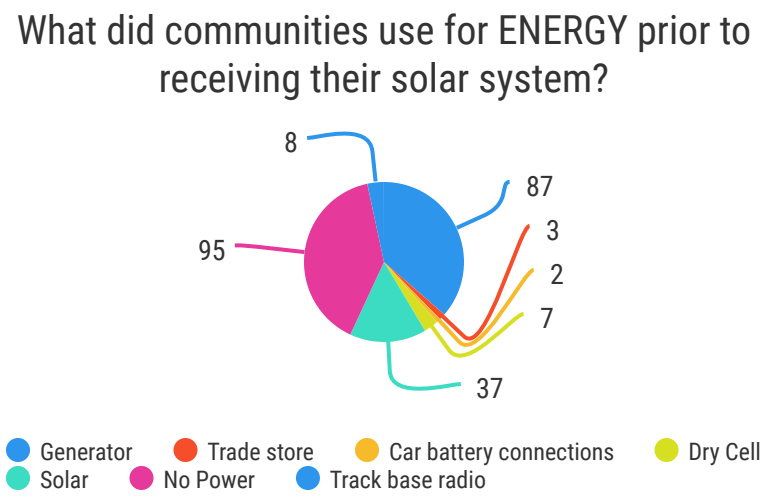
- 1 adult male
- 1 adult female
- 2 male children
- 2 female children

The following charts outline the sources of fuel and power for their lighting and energy needs prior to receiving their solar systems.

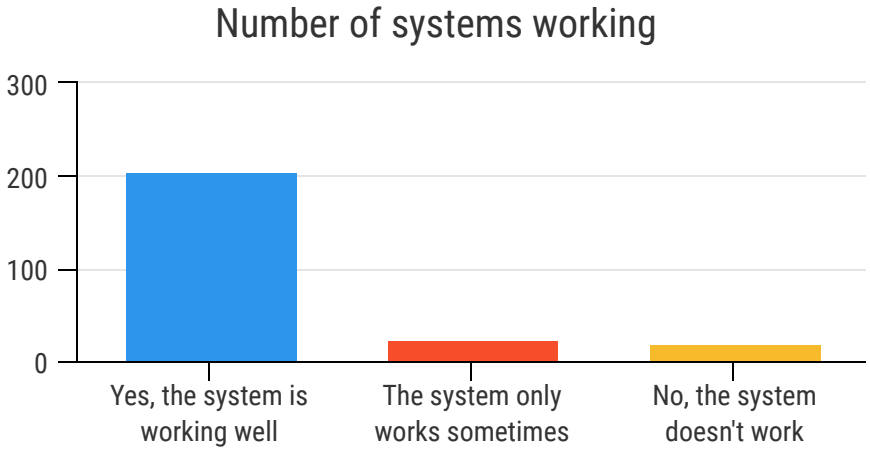


Quantitative Findings

The following charts outline the sources of fuel and power the community members reported using for their energy needs prior to receiving their solar systems.



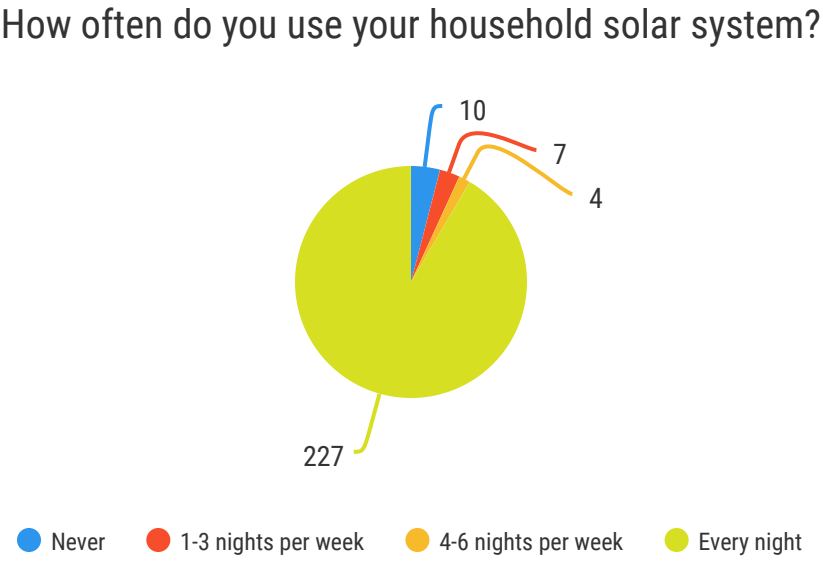
The research then examined how well the solar lighting and energy systems were still working since the household had received them. The majority of systems were still working well:



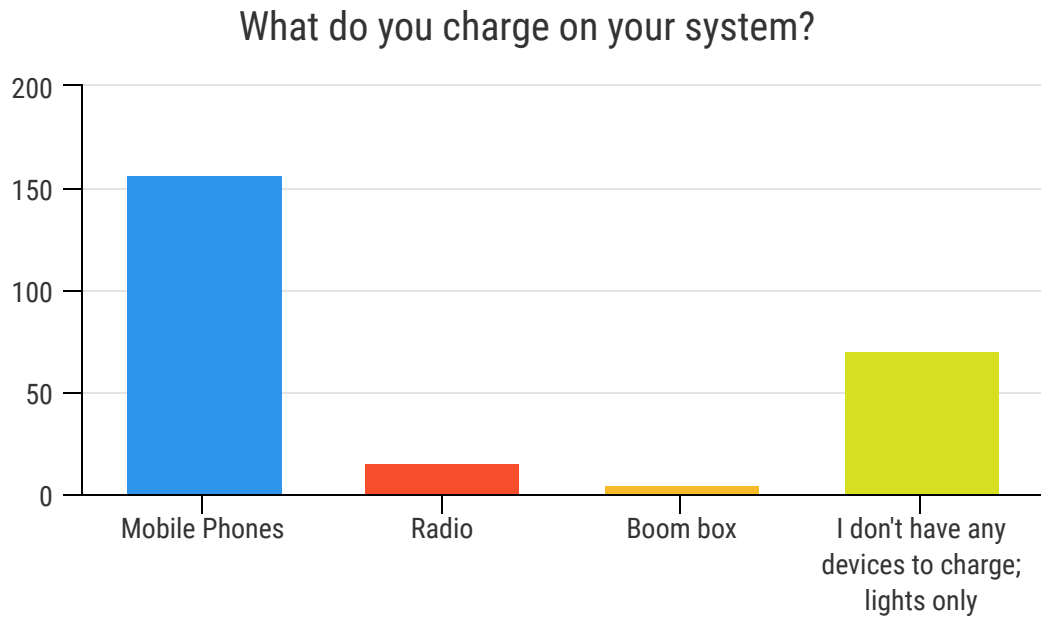
Of those who stated that their system was not working, or only working sometimes, 25% stated that this was due to rainy or cloudy days where sun coverage was not available to charge their batteries. A small number of other cases reported issues from tampering with wires and connections and community violence and ensuing damage of systems. When asked if they had to do any basic maintenance on their solar systems, only 5% of respondents replied "Yes". The main type of maintenance reported was fixing broken switches, re-wiring, and connecting the systems to inverters. The respondents stated that they had sought assistance from the people in their communities who had received the training in how to install and maintain the systems.

Quantitative Findings

Community members were asked how often they use their household solar systems. The results are outlined in the following graph:



They were then asked what devices they charge via the power charging component of the household systems. The majority of people used the systems to charge mobile phones:



Quantitative Findings

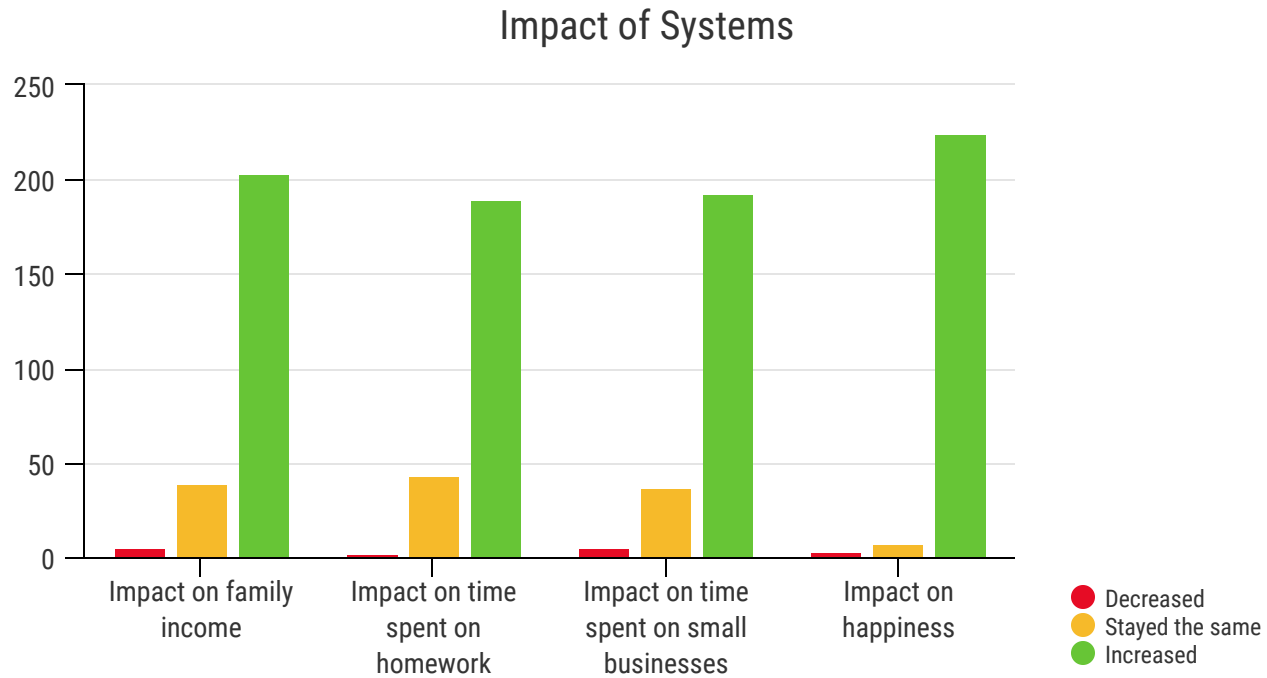
Survey participants were asked whether they had invested in any additional solar technology since the introduction of the household systems via the Village Connect project. 12% of households had purchased additional solar equipment including additional lights, batteries, panels and torches. The main driver of this was to increase power in the homes.

Survey participants were then asked whether they had been saving money in order to invest in the purchase of new batteries when the time comes for them to be replaced. 57% of respondents stated that they had already saved enough Kina for the purpose of battery replacement. A further 30% said that they knew they had to save the money but their circumstances had prevented them to begin saving, but they planned to start saving. The COVID-19 pandemic and cessation of the Kokoda trekking industry had a big impact on this.

Of those who had started saving for their battery replacement, the average amount saved was K153 - this is sufficient to purchase at least three replacement batteries (batteries are approximately K50 each in the current market).

Additionally, 67% of people stated that they had been able to save money since the introduction of the solar systems which they have been able to utilise for additional need and requirements such as school fees, food supplies, roofing iron, small businesses, and clothes and other resources for their children.

The research examined the impact of the household systems on a range of outcomes including family income, the amount of time children spent working on homework after dark, time spent working on small businesses after dark, and their level of happiness. These questions were answered on a three point likert scale and the results are displayed in the following charts:



Quantitative Findings

The survey then explored the impact that the systems had on the time that school-aged children living in each household spent on their homework after dark and asked participants to report on this comparing time spent on homework before receiving the systems compared to the time spent after they had received the systems. It is important to note that self-reporting methodology was utilised and baseline data was not collected to verify this information. Further impact assessments should collect baseline data and control group data to further elucidate the impact of the solar lights on time spent on homework.

The average time spent on homework each night before receiving the household solar system was 24 mins. The average time spent on homework each night after receiving the household solar systems was 84 mins. Across the cohort, this represented a 246% increase in time spent on homework.

The survey then explored the impact that the systems had on the amount of kerosene households spent on lighting needs and asked respondents to report on this comparing amount spent before receiving the systems compared to the amount spent after they had received the systems. Again, self-reporting methodology was utilised and baseline data was not collected to verify this information. Further impact assessments should collect baseline data and control group data to further elucidate the impact of the solar lights on amount spent on kerosene.

The average amount spent on kerosene per week prior to receiving the household solar systems was K21 (or K1,092 per year). The average amount per household spent on kerosene after receiving the household solar systems was K0.4 (or K21 per year). Across the cohort, there was a 97% average decrease in amount of Kina spent on kerosene per week.

Additionally, 98% of households reduced their expenditure on kerosene from a weekly amount to zero expenditure on kerosene; thus the lights completely replaced their reliance on burning kerosene for lighting.

The amount spent on batteries also decreased by 98%; with the average weekly spend decreasing from K6 per week to K0.15 per week. 97% of household owners completely reduced their weekly expenditure to zero.

Quantitative Findings

The survey then explored the impact that the systems had on the amount of income households earn per week working on small businesses and asked participants to report on this comparing the amount earned before receiving the systems compared to the amount earned after they had received the systems. It is again important to note that self-reporting methodology was utilised and baseline data was not collected to verify this information. Further impact assessments should collect baseline data and control group data to further elucidate the impact of the solar lights on the amount of income earned per household.

The average weekly income earned per household before receiving the household solar system was K32 per week. The average weekly income earned per household after receiving the household solar systems was K94. When examining the difference per household and calculating the overall average percentage increase, average weekly income increased by 226%.

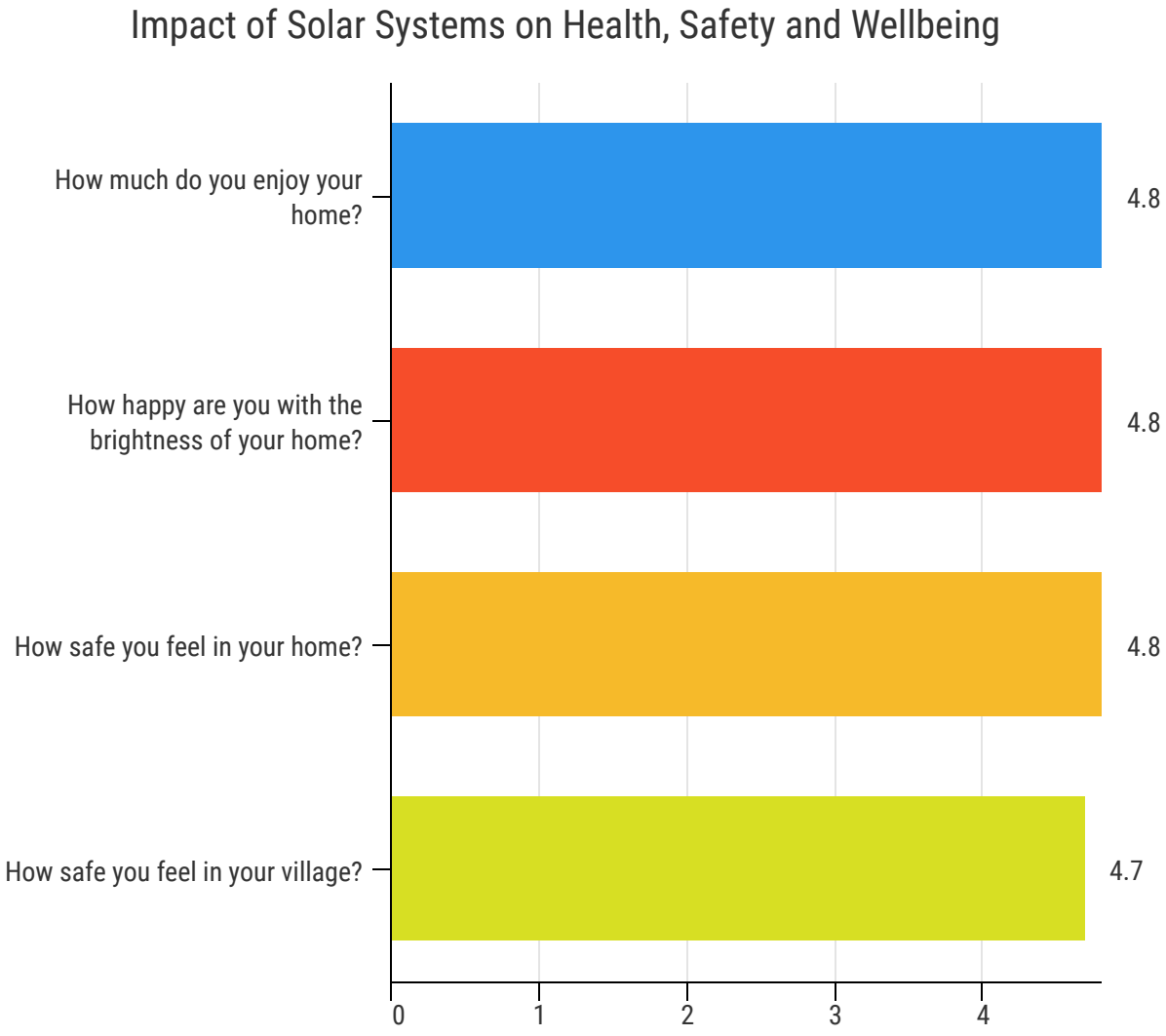
Finally, the survey explored the impact that the systems had on the amount of time members of households spent working on small businesses and asked respondents to report on any change between before and after they acquired their systems.

The average amount of time spent working on small businesses per night prior to receiving the household solar systems was 41 minutes. The average time spent working on small businesses per night after receiving the household solar systems was 2 hours 39 minutes. Across the cohort, there was a 371% average increase in the time spent working on small businesses after dark since receiving the household solar lighting and energy systems.

The main activities that were reported that household members worked on after dark included the creation of goods that could be sold at local markets (e.g. bilums, Meri blouses), operation of trade stores and canteens, small business finances and banking, and business planning and preparation, especially related to the trekking industry (pre-COVID-19).

Quantitative Findings

The final part of the survey explored the impact of the systems on a range of self-report safety and wellbeing indicators. Participants were asked to report how much impact the solar systems had on the following indicators and the results are displayed in the chart below. The likert scale ranged from 1 = Not at all to 5 = A lot and average results per indicator are displayed in the chart.



Qualitative Findings

Interviews and focus groups were conducted with a range of participants across the target region to further elucidate the quantitative survey results. 169 people participated in semi structured interviews and/or focus groups. The gender breakdown of these participants was 54% males and 46% females.

A content analysis was used to identify key themes and common areas of discussion. Content analysis is a systematic coding and categorizing approach used for exploring large amounts of textual information to determine trends and patterns of words used, their frequency, their relationships, and the structures and discourses of communication (Mayring, 2000).

A number of categories emerged from the content analysis including: impact of solar systems on academic behaviour and outcomes, perceived safety & security, ability to develop and work on small businesses, impact on activities and schedules, and better financial outcomes. These themes are discussed in the following sections.

Impact on Academic Behaviour & Outcomes

Many participants spoke about the impact of the household solar systems on academic behaviours and school outcomes among their children. Whilst the survey results clearly indicated an increase in the amount time children were able to spend working on their homework or reading after dark, the qualitative data discussed in more detail the range of positive implications the light and power access had on academic behaviours and outcomes.

Many participants spoke about the increase in time spent on homework.

"When the lights were issued, children started to gain knowledge and they would read a lot more and study at night, so they start to improve their knowledge."

"The lights have greatly benefitted our students in their studies as they can now continue to do their homework and studies at night time."

This young person spoke about their younger siblings now being in the habit of borrowing books from their school and reading them with their parents:

"Our younger siblings, now that we have the solar, our parents help them with their homework, reading activities and assignments. The young elementary students borrow books and take them home to read at night and then early the next day in class they are asked to read out loud. The solar has helped parets spend quality time with their kids and many of them now go on to school and are improving in their reading skills."

Many parents discussed the improvement that the solar systems have had on grades and educational outcomes for their children:

"Yesterday I witnessed and I am very happy with the performance of my daughter. She is a Grade 7 student and has achieved straight very high and high in all her core subjects unlike before she use to struggle in her overall performance. The solar has helped her do more studies at night that made her improve a lot."

"I have seen my children do well especially after spending more time using the solar to do their homework and studies at night time. My second born child scored all distinctions and two credits in all his core subjects. My last born child in Kindergarten, after spending more time with him on his subjects he was struggling with, he come on top second in his class, surprising me as well! The lights have not only helped the parents but the kids to do well in their academic performance."

Qualitative Findings

Impact on Academic Behaviour & Outcomes cont...

These young FODE students discussed their first-hand experience with improved academic behaviours and performance since receiving the solar systems:

"Before I received my sinking solar systems, I was doing poorly in my English subjects. After we received the solar lights, I now spend more time reading and have improved my English subject and my teacher was very happy with my efforts and performance."

"The solar has helped me to sit and work at night and to have more time to study. And it really helped me a lot to improve in my academic studies because previously I managed to only study during the daytime - after classes and it did not really help me at all. The solar really helped me to study for longer and do well in my academic results."

This student spoke about improvements in specific subject areas:

"It has helped me improve in my Maths, because I used to score below average. But with the solar, I now get to spend more time to work, I do a lot of revisions, homework, activities, extra readings as well. I not only improved in my Maths alone, I managed to improve in my History and other subjects as well."

This parent reflected on how she has been able to support her young child with his learning after dark; whereas previously he would not have much time to spend on schoolwork as he would play during daylight hours:

"Since the introduction of the solar lights, my small boy, a 6-year old, has improved. Under the peer influence, he plays a lot during the day and in the afternoons. But now, during night time, I have time to sit down with him to assist him on subjects he is not good in. And from his end of year performance, he has really improved."

This person emphasised how the solar lights are easier to study and read under:

"In the past, we used kerosene lamps and we find it very hard to study at night. It was hard on our eyes. The solar has made it much easier to learn at night and to study for many hours."

Finally, teachers discussed the impact of receiving the solar systems on their ability to complete work during the evenings including the preparation of lesson plans and other activities for school the next day:

"I am a teacher and I am so happy because the solar lighting provides good comfort and security at night time. I can stay inside the comfort of my home and do lesson planning for the kids in class during the night time."

"As a teacher, I now have enough time in the evenings to do my class lesson planning, report writing and stay up until 1am in the morning sometimes preparing all my work. I still have time to sit with my children and tell stories and enjoy family time."

This teacher also discussed the improvement he has witnessed in student grades overall since his community received the solar project:

"As an elementary school teacher, I have witnessed students improving in their academic performance and especially in their reading abilities. Previously it was very hard to get students to get much needed help from their parents at home. Students would come and complain about not having better light at home to complete their homework so I would give them extra time in the mornings to complete their homework. Now, things have changed since the solar light installation, students can also borrow books from me. I issue reading books to kids to practice at night time and then when we come in the morning, we go into our reading session and the kids read to the class. I have seen the students improve so much especially with parents helping them with their reading at home. Now many of them can read confidently in class.

Qualitative Findings

Impact on Perceived Safety & Security

Participants spoke about the impact of the solar systems on a range of perceived safety and security factors. The most common response was that the lighting enabled the household to feel safer and to know when danger was present or approaching.

"The lighting is so bright everywhere providing good security lighting. The solar lights can go further than anything before, even 10 to 20 meters away from the house. The solar light gives good security to my family and I."

"The solar light provides security light at night; we are now able to see approaching danger from a safe distance unlike previously where it is so dark and we are afraid of a lot of things."

"We feel very safe now unlike before where we were scared of the dark and especially enemies that may hide at the kitchen or near the toilet in dark places."

This person spoke of the increased sense of security when walking around the village due to the brighter security lighting:

"Before, the village was a big darkness. With solar installed at every household, we had some form of security when moving around in the village at night time. At each home, at least one lamp is used for security lighting outside of the house, making us all feel safer moving around at night time."

Another person spoke of the immense positive impact the lights have had on his sense of security and ability to now sleep soundly throughout the night; the theme of no longer being afraid of the dark again coming through strongly:

"Before the solar came, I used to act as the security guard for my household. I would sleep but not sound sleep, keeping watch on my family as anything can happen in pitch black darkness. My wife and kids are afraid of the dark as well and when the solar came, we all were very happy because now we have good lighting inside and outside and the house is secure."

During a women's-only focus group, women spoke about the lights providing safety and security from threatening animals and "raskols" (criminal gang members) and violent or threatening intruders:

"My house is just a few meters away from the coast line. The SunKing solar that you gave has provided sufficient light that keeps the crocodiles away from our home. Previously, without good lighting, the crocodiles come under our house and have taken our cats, dogs and even children some years ago. But with the solar lights now it keeps the crocodiles away. Also I have banana garden or buai trees that raskols come in the night and steal. But the most important thing is that crocodiles are kept away from the house."

"The solar security lights keep young men away from my house. I have young girls in my house and the boys like to come around our house and peep into girls' rooms in the cover of darkness, spy and harass the girls. This does not happen anymore."

"My house is in the grasslands. The security lamps outside the house and lamps inside the house are bright and so they keep uninvited guests like big bush rats and snakes away from our houses. I have seen this and am very happy, unlike before I used to be afraid in my own house."

"I have a chicken poultry near my home, the light provides good security and it keeps raskols and animals away from the chicken coup, keeping all my chicklets and chickens safe from danger of snakes, people and rats. I can clearly see who wants to come and steal my chickens."

Qualitative Findings

Impact on Perceived Safety & Security cont...

Another woman spoke about her improved sense of security that the solar lights have brought to her, especially when her husband was away from the home:

"My house is far away from the village and my husband goes out to hunt at night. The solar light is my security especially when my husband is out of the house hunting."

Likewise, younger people spoke of the security the lights provided when their parents were away from the home:

"When my father is out of our home and we are by ourself with mum, the solar light gives us comfort and a sense of security. Because with the brightness of our light we can easily see who is entering our area; knowing this gives me comfort and peace not to worry when my father goes out."

"Since the Sunking solar came into the village everyone has good lighting and when our father is out on the trek, we stay with our mother and we still feel safe. With the security lighting, we can see who approaches the house or is near our house."

"When my mum or dad are out of the house, I am the security to my younger siblings. With the lights I feel secure and I go to sleep while keeping alert to whoever may approach our house. The light makes it easier for me and I am not often worried unlike before."

Finally, participants spoke about the lights providing security to their resources and possessions:

"I feel secure and safe now because I have precious trekking gear and items in my household and having solar light provides bright light. I do not worry too much because in the dark while asleep raskols can come and steal; but with good lighting, it provides security to my household."

Improved Productivity

Many participants spoke about the impact the solar lighting systems have had on their ability to be productive and in particular to work on small income-generating businesses.

"My wife and I do some small table marketing of rice, noodles and biscuits; solar lights help us to stay up a little longer at night to do our selling."

"Those of us involved in small business table markets now have extra hours for sales after dark using the solar. Our mothers found it difficult to cook and do many other things during the night but with solar they can do cooking at night and doing many other things became possible."

Young people spoke about helping their parents with small businesses after darkness has fallen in the evenings:

"Apart from doing my studies, my Dad has a small canteen trade store. I help him stay up until 10pm and close up the canteen each evening."

"Apart from doing my school work, I wake up with my mother very early and help her make dough and fry doughnuts for selling to students and the community early in the morning before school starts."

Qualitative Findings

Improved Productivity cont...

Many women spoke about the savings they made from reduced expenditure on kerosene and batteries for light, allowed them to start small businesses and make start-up investments:

"Before, I used to spend a lot of money on batteries, Now I don't spend money on batteries anymore. The money is used to pay for school items like shoes for my kids and I also used it to pay for my sales table to market items and starting up my table market business. I am now a happy woman living in the light, enjoying my light, running my successful business with zero spending on batteries!"

"Now, I don't spend any money on batteries or kerosene. Instead, I have saved more money and I use some of it to buy bags of flour to cook doughnuts for sales to raise more money for my family."

The lighting up of businesses at night was discussed as a major factor that allows people to know that canteens and other markets are still open for business:

"Before the solar lights, my husband has a small trade store and before he had to use a small kerosene lantern in the night. And so a lot of people in the community do not know if the canteen is open or not. But now with the solar lights people can clearly see that the canteen is still open and can come and buy their things and we stay up late until we want to close the canteen."

"My wife and I have a small table where we sell store goods and the solar system helps us to conduct sales like biscuits coffee, buai and smokes up until 11pm or even 1am. The light makes people see that we are still doing our sales; so it attracts customers to our table. With the Sunking, I can stay open for longer hours and sell more items earning more cash and allowing more cash flows."

Other people spoke about the light enabling them to work on crafts and weaving activities that they could then sell to tourists and at markets:

"I am very happy because now after dinner, I can sit up and weave mats or bilums until the breaking dawn. Also I can wake up early at 4am to cook my doughnuts for selling the next days. Unlike before, I have to wait until dawn when the sky is clear and I can come out to cook; but now I can make my dough at 4am and start cooking my doughnuts."

"The solar lights makes life more interesting. I stay up late, til the breaking dawn sometimes, almost every night rolling tobacco in small rolls and packages for selling. While my wife makes bilums for market sales to trekking tourists."

Change in Activities, Schedules & Mindsets

Other themes emerged from the focus groups and interviews about the impact the lights and energy systems have had on changed schedules and the opening up of opportunities to engage in new activities.

This person spoke about the changes in their daily schedule and the fact that people now have more hours in the day:

"Adults in the houses can now stay up late, telling stories while mothers weave their bilums. Before the solar installation, everyone slept soon after dark, as nothing much can be done in poor lighting. Now, everyone in the house is enjoying doing their other activities and can sleep at 9, 10 or 11pm."

Qualitative Findings

Change in Activities, Schedules & Mindsets cont...

These participants spoke about the range of new activities that people were undertaking, now that there was light and power and more time in each day:

"My Dad was able to save some money to buy a 950 Volt solar panel and TV screen. Now during the school holidays and weekend periods, we enjoy watching movies at home in the village for the first time ever!"

"The solar has basically changed the lives of the community because now every house has lights in their homes and they can see well now. We enjoy our dinner time, sitting outside, hosting our family friends, having small meetings, discussions about community issues and so on under the solar lighting. Also, important health improvement when preparing meals and eating in the dark were previously not good with no lighting and we didn't know if we were cooking food with dirt or are eating with dirt."

"The solar light has given us a big help. During the day we have sunlight and now during the night we can carry on with other activities because we have good lighting in the night to carry on, unlike before. The elderly people now enjoy the evening time unlike before where they go straight to bed as soon as the sun sets."

These younger participants spoke about life becoming more interesting since receiving the solar systems:

"With the solar installed at our home, we can enjoy telling stories with our friends until late, charging our phones, or boomboxes to listen to music or watch videos and it is much easier for us and our younger siblings to study and read books at night."

"I was living in the dark previously and it was very hard. But after I got the Sunking system, life after dark at home for myself became interesting. My family and I can see well, cook and serve dinner in the light, kids enjoy playing, looking at picture books, we tell stories, host our friends and families when they visit, and we really enjoy using the solar light at night time."

Finally, a theme emerged around changed mindsets and innovation. This person discussed the new opportunities that the lighting and energy systems have given to people in his village:

"The lights have changed the mindset of the young males in the community. I work with some of the youths in kick-boxing training and I want them to continue in that sportsmanship including their education level in school and onto Colleges and Universities. I have seen life has changed very much at the village level. Young boys and girls have changed mentality with the lights on in their homes, enabling them to think outside of the box and about what they can do for themselves or for the community. School kids are improving and excelling in their studies because of good lighting at home and people are happier in general."

Improved Financial Outcomes

Finally, the theme of improved financial outcomes emerged strongly across the focus groups and interviews, with most participants talking about the positive impact of the project on their ability to save and earn an income. Participants spoke about life becoming easy and directly linked this to the cost savings associated with receiving the systems:

"Things used to be very hard, difficult for us to study and do other things when we were living without any source of good lighting. When we were given the solar systems, life became very easy. We were able to charge our phones for free in our homes, saving us K2 each time we needed to charge!"

Qualitative Findings

Improved Financial Outcomes cont...

Participants spoke regularly about what they were able to do with the funds saved as a result of reduced expenditure on kerosene for hurricane lamps and batteries for totes:

"The amount of money used on fuel, kerosene or batteries is now saved and used for other expenses such as kids' school fees and mostly on other household needs like children's clothes, lunch money, soap and general food items."

"Now I spend less on batteries. I was able to save up K3,000. This money was used on items I needed to invest in my business, my guesthouse, like mattresses, blankets, pillow etc. I also have been able to purchase some PVC pipes and have connected water near my house and guest house for my family and guests to have easy access to drinking and cooking water."

This participant spoke about the critical importance of saving money on batteries and fuel especially during the COVID-19 pandemic when the Kokoda region was impacted by the cessation of the trekking industry:

"Since we don't spend money on batteries or kerosene, that money is now used on our basic needs like food supplies, soap and laundry detergents. To save money during this time has been so important and difficult because of COVID-19 that completely stopped the trekking from being open for business. During this time, when the treks stopped operating, we had no ideas or ways to earn alternative income. We are all in financial jeopardy to meet our needs and wants and so the money saved from the solar made a real difference."

Finally participants spoke about their ability to save money and purchase additional solar technology; or spoke about saving up for the battery replacements when the time comes:

"I have a big house and the three lamps were not enough to light up the whole house; So with the money I saved from not spending it on batteries I purchased one more solar kit and used the lamps to light up the whole house so everyone in the house has equal lighting to all parts."

"I am saving up K50 to have it in place and ready to replace my solar battery when my sunking solar battery eventually weakens and needs replacing. We are willing to do this because we have seen the benefits of using a solar light and will save up to purchase our batteries."

The qualitative themes have further elucidated the quantitative survey results and have highlighted the vast and great impact the solar lights and energy systems have had on a range outcomes including academic behaviours and outcomes, improved productivity, increased sense of safety and security, changes in activities, schedules and mindsets, and improved financial outcomes and livelihoods.

Discussion

The results of the Village Connect evaluation were overwhelmingly positive. The household solar systems have had a very positive impact on a number of education, safety, financial and wellbeing outcomes for people living in remote and rural catchment region of the Kokoda Track.

The key findings are summarised here:

Education

Participants reported a 246% increase in their children's time spent on homework after dark since receiving their solar systems. Qualitative data confirmed the positive impact of the systems on study time, academic results in schools, and the amount of time parents spent with their children supporting them to complete their school work after dark.

Safety & Security

Sense of safety and security among participants was high with the average score (out of 5) for sense of safety in the home being 4.8 and sense of safety in the village being 4.7. Qualitative data confirmed that people felt safer from threats including intruders, raskol gangs, and dangerous animals including snakes and crocodiles. Women also reported feeling safer in their homes.

Financial Outcomes

Participants reported a range of positive financial outcomes including a 97% decrease in expenditure on kerosene and 98% decrease in expenditure on batteries with the majority reducing expenditure to K0. Average weekly income also increased by 226%. Qualitative data confirmed the positive impact of the project on people's ability to save and confirmed people were saving money for battery replacement and spending saved income on a range of household and personal needs.

Productivity

Participants reported an increase in productivity including a 371% increase in the amount of time they spent working on small businesses after dark. Qualitative data explored a range of small businesses that improved as a result of the lighting and energy systems including small canteens and trade stores, and the making of mats, bilums and other arts and crafts to sell at market. The availability of lighting increased the number of productive hours per person per day.

Discussion

Implications & Recommendations

The health benefits of reducing kerosene use in households have been widely documented (WHO, 2014; Pollinate, 2014; IFC, 2010; Lam et al., 2012). Exposure to kerosene is a proven risk factor for respiratory disease, lung cancer and other illnesses. The significant reduction in kerosene use by households (most to K0 expenditure) represents a positive step towards a reduction in the prevalence of these diseases in these remote communities.

Whilst the direct health benefits arising from this reduction in kerosene to the families in the evaluation were not measured during this assessment, they were discussed during the semi-structured interviews and focus groups. Adults and children spoke about the negative side effects of kerosene in their lives prior to receiving the household solar systems including making their 'eyes sore', 'lungs hurt', and breathing in 'toxic smoke'. Some people spoke about how these symptoms were reduced as a result of no longer having to burn kerosene simply as a source of light.

The impact of increased time spent on homework was clearly discussed by teachers, parents and students alike. Whilst the literature is unclear on direct causality between homework time and academic outcomes, the current evaluation suggests that other factors are also at play. The students in the study have transitioned from very little study time, opportunity to learn from and engage with parents in home-time learning, and limited opportunities to engage in reading and other academic activities at home. Not only has the prevalence of light and power enabled children to complete homework after dark and increase their daily amount of time spent on homework, the qualitative data emphasised the other positive activities that were made possible by the lighting and power including increased engagement between parents and their children on school activities, book borrowing schemes introduced by schools and teachers, and improved agency among students to complete their chores and other home based activities and still have time to undertake study, homework or reading at night.

This study did not directly measure the impact of receiving the systems on actual educational outcomes, i.e., quantitative analysis of student academic outcomes, attendance and progression through education. Further evaluations will need to explore opportunities to measure the impact of the introduction of the the systems across the region on student grades and commitment to and enjoyment of their education. Qualitative data however from teachers, parents and students indicated that the lights did have a real and positive impact on educational outcomes.

Further semi-structured interviews and focus groups should explore the longer term impact of studying via solar lights instead of kerosene lanterns on student performance and educational outcomes. The relationship between homework and educational outcomes is complex regardless of the educational setting; and so a qualitative approach may be the most appropriate for adopting in future evaluations.

Finally, the evaluation highlighted the positive impact the lighting and energy systems had on a range of productivity, safety, wellbeing and happiness outcomes. There was strong consensus across the quantitative and qualitative data that the solar systems resulted in overwhelming positive impacts across these outcomes and that adults were not only able to save money from reduced expenditure on fuel, batteries, kerosene and charging stations; but that they were more productive due to the increased number of productive waking hours and opportunities to work on small business activities during the evening after household chores and child-care activities had been completed.

A number of improvements to the methodology can be made for future impact assessments. Recommendations include:

- Self-report should be used alongside other more direct outcome measurements including school grades, attendance records, health records, kerosene usage, family incomes and family savings;
- Collection of base-line and follow-up data to more directly track changes in education, health etc outcomes;
- Impact on understanding of solar technology and likelihood for students, parents and others to commit to sourcing renewable sources of lighting and energy rather than reverting to kerosene and wood fires could be measured.

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