UHASSELT

KNOWLEDGE IN ACTION

Faculteit Bedrijfseconomische Wetenschappen

master in de toegepaste economische wetenschappen: handelsingenieur

Masterthesis

An optimal business model for a new energy innovation in the Sichem centre in Dzogblakopé Lomé (Togo)

Lore Van Welde

Scriptie ingediend tot het behalen van de graad van master in de toegepaste economische wetenschappen: handelsingenieur, afstudeerrichting technologie-, innovatie- en milieumanagement

PROMOTOR :
dr. Nele WITTERS

COPROMOTOR :
Prof. dr. ir. Wim DEFERME

UHASSELT

KNOWLEDGE IN ACTION

www.uhasselt.be
Universiteit Hasselt
Campus Hasselt:
Martelarenlaan 42 | 3500 Hasselt
Campus Diepenbeek:
Agoralaan Gebouw D | 3590 Diepenbeek

2017
2018

Faculteit Bedrijfseconomische Wetenschappen

master in de toegepaste economische wetenschappen: handelsingenieur

Masterthesis

An optimal business model for a new energy innovation in the Sichem centre in Dzogblakopé Lomé (Togo)

Lore Van Welde

Scriptie ingediend tot het behalen van de graad van master in de toegepaste economische wetenschappen: handelsingenieur, afstudeerrichting technologie-, innovatie- en milieumanagement

PROMOTOR :

dr. Nele WITTERS

COPROMOTOR :

Prof. dr. ir. Wim DEFERME

Preface

This written master thesis was submitted to obtain the master degree in business engineering at Hasselt University, with a major in technology, innovation and environmental management. This research tries to develop a business model that can be implemented in the Sichem centre in Togo to enable them to use a renewable energy installation in the long term. In this preface I would like to thank all the people that supported me during the process of writing my master thesis.

First, I would like to thank my promotor dr. Nele Witters, my co-promotor prof. dr. ir. Wim Deferme and my external advisors dr. Dries Maes and Isabel Bonjean for the feedback, the good advice and the support.

Second, I would like to thank NGO SEA and NGO Togo Debout. NGO SEA enabled the engineers to build an energy installation and innovation for the Sichem centre with their financial support. Without this money, it would have been impossible for me to develop a business model for an innovation that would have never been built. Kaz Puttenaers and Daan Droogmans also provided me with information such as the costs made, which was really valuable. NGO Togo Debout supported me from a more practical point of view before, during and after my stay in Togo, helped me achieve the goals of my stay in Sichem and supported me emotionally during this stay as well.

Third, I would like to thank VLIR-UOS and Hasselt University for their financial support that enabled me to travel to and stay in Togo.

Fourth, I want to thank the Sichem centre, not only for the warm welcome, the practical support and the friends made, but also for the help with the surveys. More specifically, I want to thank Antoine Dzamah – the head of Sichem, Arsène Attidokpo – my local supervisor, Ria Etienne – the local representative of Togo Debout and my questionnaire team – Eugénie, Assouppi, Pierre, Paul, Sandrin and Bertine. Without them, it would have been impossible to finish this master thesis.

Lastly, I would like to thank my parents, sisters, boyfriend and friends. They supported me during this adventure, stood always by my side and helped me whenever possible. Without their support, my adventure in Togo would have been a much bigger challenge than it already was. I also want to thank my family for the (mental) support during my whole study career and especially for their endless patience. Without the chances they gave me, I would never be where I am now. I also admire them for their courage to review this master thesis.

Lore Van Welde

Rillaar, May 2018

Samenvatting

Sichem is een ontwikkelingscentrum gelegen in Togo, op een 20-tal kilometer van de hoofdstad Lomé. Sichem houdt zich bezig met verschillende activiteiten die onder meer bijdragen tot de verdere ontwikkeling van de omliggende dorpen. Het centrum heeft echter een elektriciteitsprobleem: het elektriciteitsnet waarop ze zijn aangesloten, heeft regelmatig te kampen met stroomonderbrekingen. Hierdoor kunnen ze niet steeds de geplande activiteiten laten doorgaan en moeten ook nog andere energiebronnen gebruikt worden, zoals hout en gas. Om dit te verhelpen, wordt een hernieuwbare zonne-energie-installatie gebouwd voor het Sichem centrum door twee ingenieursstudenten, welke bestaat uit 6 zonnepanelen en 4 batterijen. De zonnepanelen wekken gedurende de dag elektriciteit op die wordt opgeslagen in de batterijen. Deze installatie helpt Sichem om stroompannes te overbruggen en 's nachts de noodverlichting te laten branden, maar zal enkel werken wanneer geen elektriciteit via het net wordt geleverd. Sichem kan via deze installatie dus niet op elektriciteitskosten besparen. De installatie vergt echter extra inspanningen van Sichem, zoals het onderhoud. Om gebruik op lange termijn te verzekeren, is net dit onderhoud cruciaal zodat de installatie niet stuk gaat. Het einddoel van deze thesis was bijgevolg het bekomen van een business model voor een hernieuwbare energietoepassing, die voldoende motivatie opwekt voor het centrum naar lange termijn gebruik en onderhoud. De innovatie zorgt voor de nodige motivatie door een inkomstenstroom te genereren die stopt indien de installatie stuk gaat en die Sichem in staat stelt om voor onderhoud te betalen. De gekozen innovatie is een powerbank die wordt opgeladen via het elektriciteitsnet in Sichem indien er geen stroompanne is. Deze powerbanks kunnen dan door de dorpen rondom, waar nog geen net beschikbaar is, gebruikt worden. Drie verschillende powerbanks, met elk andere toepassingen zoals het opladen van gsm's, een radio laten spelen of een televisietoestel laten werken, werden bevraagd bij de bevolking.

Eerst werd onderzocht wat de huidige (energie)situatie was van Sichem en de omliggende dorpen. Hieruit bleek dat Sichem voornamelijk elektriciteit gebruikt voor activiteiten als siroopproductie en het geven van opleidingen. In de dorpen worden vooral andere energievormen gebruikt doordat er geen net beschikbaar is. Hout wordt voornamelijk gebruikt om te koken en verlichting gebeurt veelal met lampen op afzonderlijke batterijen.

Ten tweede werd gekeken naar de karakteristieken die de zonne-energie-installatie en de powerbanks zeker moesten bevatten opdat ze aanvaard zouden worden door zowel het centrum als de gebruikers van de powerbanks. De belangrijkste karakteristiek voor zowel de zonne-energie-installatie als voor de powerbanks bleek kwaliteit van het materiaal te zijn, voornamelijk voor de batterijen die de energie opslaan, aangezien deze geregeld stuk gaan door de weersomstandigheden. Andere belangrijke karakteristieken voor de powerbanks waren de compatibiliteit, de transporteerbaarheid en de prijs. Deze informatie werd doorgegeven aan de ingenieursstudenten, opdat zij dit in rekening konden brengen bij het ontwerp van de installatie.

Ten derde werd onderzocht of de lokale bevolking geïnteresseerd was in de drie verschillende powerbanks. Dit werd gedaan aan de hand van een vragenlijst die de oplaadmethodes bevroeg, de kosten hiervan en de mogelijke interesse in elk van de powerbanks. Deze vragenlijst bevroeg ook de

willingness to pay (WTP) van de bevolking voor deze powerbanks via de *double-bounded dichotomous choice* (DB-DC) methode. In totaal werden 347 bruikbare vragenlijsten afgenomen in vijf verschillende dorpen. Na analyse van de antwoorden werd de tweede powerbank gekozen als meest belovende optie. Deze powerbank kan niet alleen tot 100 gsm's opladen, maar kan ook lampen en radio's laten werken. De berekende WTP hiervan bedraagt 4.459,98 CFA per ontlening. Met een wisselkoers van ongeveer 655 CFA per euro komt dit neer op 6,81 euro. Deze WTP ligt lager dan de minimumkost die een gezin maakt om 100 gsm's op te laden, aangezien een enkele oplaadbeurt tussen de 50 en 100 CFA kost. De hoogte van deze WTP wordt beïnvloed door de leeftijd van de respondent en de grootte van het gezin. Hoe meer gezinsleden de respondent heeft, hoe hoger de berekende WTP. Bij de leeftijd geldt het omgekeerde: hoe ouder, hoe minder de respondent bereid is te betalen voor een dergelijke powerbank.

Ten vierde werd een business model uitgewerkt dat Sichem in staat stelt om de powerbank op een goede manier te beheren zodat hier winsten uit voort komen om het onderhoud te betalen. Dit model werd opgesteld vanuit een duurzaamheidsperspectief. Het model omvat een huursysteem voor 20 powerbanks dat georganiseerd wordt vanuit de bibliotheek van Sichem. Deze powerbanks worden verhuurd aan gezinnen van de vijf omliggende dorpen voor de prijs van 2.500 CFA met tevens een vereiste waarborg van 1.500 CFA te betalen bij de eerste ontlening. De voornaamste kosten om dit mogelijk te maken, zijn de investeringskosten die gemaakt werden door de vzw SEA en de ingenieursstudenten Kaz Puttenaers en Daan Droogmans. Daarnaast zijn er ook oplaadkosten (elektriciteitsverbruik) en onderhoudskosten (loon voor onderhoudstechnieker). Met deze kosten reeds ingerekend zou Sichem op 15 jaar tijd een winst kunnen maken van 6.515.000 CFA, wat hen de kans geeft om kapotte powerbanks te vervangen alsook nieuwe aan te kopen om het systeem uit te breiden. Doordat de gebruikte cijfers voor het loon niet vast te bepalen zijn en doordat een vaste waarde gebruiken afwijkingen kan veroorzaken, werd een Monte Carlo simulatie uitgevoerd. Hieruit bleek dat de kosten met 100% zekerheid onder de 1.500 CFA blijven. Een winst van 1.000 CFA per ontlening kan dus worden verzekerd. Wetende dat een zakje water 25 CFA kost en een maaltijd langs de weg al voor 100 CFA gevonden kan worden, is dit een relatief hoog bedrag, maar is dit zeker niet onoverkomelijk.

Summary

Sichem is a development centre in Togo, situated approximately 20 kilometres east of the capital Lomé. Sichem engages in different activities that contribute to the further development of the villages surrounding it. The centre has an electricity problem: the electricity network, with which they are connected, knows many breakdowns of sometimes even hours. Due to this, the planned activities sometimes need to be cancelled or rescheduled and other sources of energy, such as wood and gas, need to be used as well. To ameliorate this situation, a renewable energy installation is built for Sichem by two engineering students, consisting of 6 solar panels and 4 batteries. These solar panels produce energy during the day, which is stored in the batteries. This installation thus helps to overcome breakdowns and to provide emergency lighting when it is dark. However, it only delivers electricity during those breakdowns, which means that no money on electricity is saved. The installation also demands some extra efforts from Sichem, such as maintenance. To ensure long term usage, this maintenance is crucial to prevent the installation to break down. The overall objective of this master thesis was therefore to develop a business model for a renewable energy innovation that creates enough motivation for Sichem for the long term usage and maintenance. This innovation provides motivation by inducing a revenue stream which stops when the installation breaks down and which enables Sichem to pay someone for the maintenance. The chosen innovation is a powerbank, which is charged using the electricity network when no breakdown occurs. These powerbanks can be used by the villages surrounding Sichem, where no electricity network is available. Three different types of powerbanks with the options of charging mobile phones, powering a radio and providing light, were proposed to these inhabitants through a questionnaire.

First, the current (energy) situation of Sichem and the surrounding villages was looked at. This investigation showed that Sichem mostly uses electricity as energy source and uses it for many different activities, going from syrup production to organising trainings. In the villages, the most used energy form is wood, since no electricity network is available here. Wood is mostly used for cooking and lighting is mostly provided by external flashlights that work on (non-rechargeable) batteries.

Second, it was identified which characteristics were the most important and thus needed to be implemented in the solar installation and the powerbanks so that they would be accepted by both the centre and the users of the powerbanks. The most important characteristic for both the solar installation and powerbanks to account for was the quality of the material, especially of the batteries used since they tend to break down rather fast due to the weather conditions. Other important characteristics for the powerbanks were compatibility, transportability and the price. This information was provided to the engineering student so that they could take it into account when designing the installation.

Third, there was looked at the interest of the local population in the three different powerbanks. This was done through a questionnaire, which surveyed the charging methods, the costs hereof and the possible interest in each of the powerbanks presented. Further, the questionnaire surveyed the *willingness to pay* (WTP) of the respondents for these powerbanks, using the *double-bounded*

dichotomous choice (DB-DC) method. In total 347 useable questionnaires were conducted in five different villages. After the data analysis, powerbank number two was chosen as the most promising option. This powerbank can not only charge 100 mobile phones, but also power a radio and provide lighting. The calculated WTP of this option amounts to 4,459.98 CFA per rental. With an exchange rate of approximately 655 CFA per euro, this equals to 6.81 euro. This WTP is lower than the minimum cost a family has to make to charge 100 mobile phones somewhere, since a single recharge costs between 50 and 100 CFA. The height of the WTP is influenced by the age of the respondent and by the size of the family. The more family members a respondent has, the higher the calculated WTP. The opposite goes for the age of the respondent: the older, the less one is willing to pay for a powerbank.

Fourth, a business model was developed, which enables Sichem to manage the powerbanks in the right way so that revenues and even benefits are obtained and so that the maintenance can be paid for. This model was designed starting from a sustainability perspective. The model comprises a rental system with 20 powerbanks, which is organised from the library of Sichem. The powerbanks are rented to the families of the five surrounding villages for the price of 2,500 CFA and a deposit of 1,500 CFA is required for the first rental. The most prominent costs of this business model are the investment costs made by NGO SEA and the engineering students Kaz Puttenaers and Daan Droogmans. Besides that, also charging costs (electricity usage) and costs of maintenance (the wage of the responsible employee) are present. Taking into account these cost, Sichem would be able to make 6,515,000 CFA profit over 15 years, which enables them to replace broken powerbanks as well as to expand the system by buying extra. Since the wage of the employee for the maintenance is quite flexible and since using a fixed value might cause deviations, a Monte Carlo simulation was carried out using different values for the wage. This showed that the costs remain under 1,500 CFA with 100% certainty. Therefore, a profit of 1,000 CFA per rental can be made. Knowing that a small water bag costs 25 CFA and a meal along the road can already be found for 100 CFA, this could be seen as a relatively high amount, but it is not insurmountable for sure.

Table of Contents

List of figures

List of Tables

Clarifications

CFA	Abbreviation for "Communauté Financière Africaine", which is a community that uses the same currency. This currency is used in West-African countries that speak French as well as in countries in Central-Africa. €1 ≈ 655 franc CFA. (Banque Centrale des Etats de l'Afrique de l'Ouest, 2018; Finance Network, 2018)
CO_2	Carbon dioxide
CV	Contingent valuation
DB-DC	Double-bounded dichotomous choice
HDI	Human development index
KWh	Kilowatt hour, or the amount of kilowatt used in one hour
NGO	Non-governmental organisation
SEA	Students for Energy in Africa
STATA	Name of a statistical program
VZW	Vereniging zonder winstoogmerk, is the same as an NGO
WTP	Willingness to pay

1 Introduction

During the academic year of 2017-2018, two master students of engineering science (Droogmans, & Puttenaers, 2018) went to the Sichem centre, nearby Lomé, in Togo. Their purpose was building a renewable energy installation, in collaboration with the NGO "Students for Energy in Africa", also called NGO SEA, and NGO Togo Debout. NGO SEA is a Belgian organisation with on the one hand the objective to realise sustainable energy projects in Africa and on the other hand the objective to increase the knowledge of both the students and the local population (vzw Students for Energy in Africa, 2017). NGO Togo Debout is a Belgian organisation with an official representation in Togo and with multiple objectives, like supporting local development projects in Togo. Togo Debout is very active in the Sichem centre, since the head of the centre is also one of the founders of the NGO (Togo Debout VZW, 2018). The Sichem centre, hereinafter Sichem, is a centre that combines many different activities: a primary school, a farm, a butchery, a refuge for children living on the streets or in conflict with the law, a little factory for processing local fruit into exportable syrups and jams, transformation of Artemisia Annua into infusion tea and capsules, a library, an IT-formation, a formation for cultivators, a sewing atelier, accommodation for foreign volunteers… Due to this large amount of activities, Sichem needs cheap, sustainable and reliable energy supply. Previous energy projects of NGO SEA have proven that such projects are very likely to greatly succeed on a technical level, but also that these energy installations are not used perpetually. The main reason therefore is that the installations do not always meet the needs, wishes and expectations completely. Moreover, the installations are designed to meet the current needs of a centre or population without creating an extra stimulus for the users, even though there are extra efforts required, like buying new batteries or turning on a switch. Mostly, for the users this effort will not be compensated by the advantages of the installation itself and the installation will be put aside in the long term.

In order to avoid that the installation will (barely) not be used by Sichem, an extra add-on was sought to motivate the community to make these extra efforts. This add-on is an energy innovation that will create surplus value for the centre and the people in the surrounding villages. This will create extra profit for Sichem, which increases the chance of permanent usage of the installation, but at the same time, it helps with the further development of the villages close to Sichem. Since searching for add-ons and developing a business model is not the core business of engineering students, it was decided that the faculty of Engineering Sciences and the Faculty of Business Economics of Hasselt University join forces in this project in order to extend the chance of long term usage. As a student business engineering in my final year of masters, my master thesis addressed this topic.

2 Problem statement

In order to better understand the problems in Togo, a short summary of the country is given. Afterwards, the specific problems addressed in this master thesis are explained.

Togo – officially the Togolese Republic or République Togolaise – is a West African country with the capital called Lomé. Togo, indicated on figure 1 below, has three different neighbouring countries – Ghana, Benin and Burkina Faso – and is connected to the Atlantic Ocean in the South.

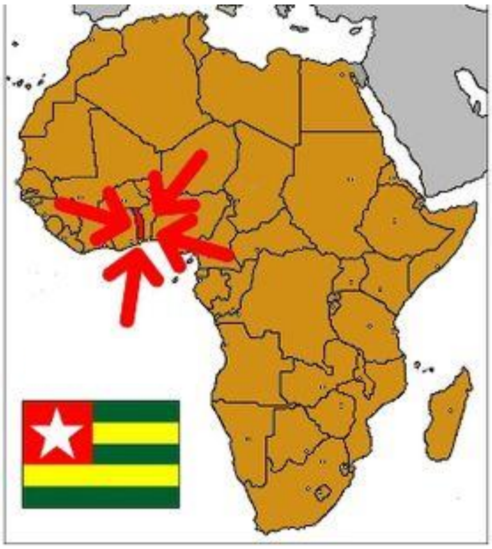

Figure 1: Map of Africa, with Togo marked, and the Togolese flag in the left corner below (Compari, 2013)

Togo has a population of 7,965,055 people within an area of 56,785 km², which results in a population density of 140.27 people per km². According to the CIA World Factbook (Central Intelligence Agency, 2018), this is one of the more densely populated African countries. The official language is French, but the local languages Ewe (in the South) and Kabye (in the North) are mostly spoken among the people, especially in the rural areas. The Togolese population knows a rather strong growth rate of 2.64%. 60% of the population is younger than 25 year, which can be explained by the high number of children per woman (4.38). The current life expectancy at birth is 65.4 years old, which places Togo on the 177th place of the world (total of 224 countries). Health conditions need improvement, since only 0.7 hospital beds are available per 1,000 people, 2.1% of the adults suffers from HIV/Aids, 16.2% of the children younger than 5 is underweight and 6.9 per 1,000 people die. Furthermore, 47% of the children between 5 and 14 year is involved in child labour (Central Intelligence Agency, 2018). An index that is informative about the development of a country, is the Human Development Index (HDI). The HDI index is composed of three different dimensions – long and healthy life, knowledge and decent standard of living – and emphasises that people and their capabilities are at least equally important as economic growth to evaluate a country's development (United Nations Development Program, 2016b). Togo has an HDI index of 0.487, which places it on the 166th place out of 188 countries. Norway is being ranked first with an HDI-index of 0.949, and Belgium 22nd (United Nations Development Program, 2016a). Togo is doing slightly better than its neighbouring countries Burkina Faso (185th) and Benin (167th), but is nevertheless classified under "low human development" (United Nations Development Program, 2016c). All these numbers give a first indication of the development needs of the country.

In Togo, there are 5 million people who do not have access to electricity. In the rural areas, the electrification percentage is only 21%, compared to 35% in the urban areas. Moreover, on a yearly basis, the Togolese population emits 1.8 billion of ton CO_2 due to their consumption of energy (Central Intelligence Agency, 2018). These numbers show that, in order to develop further and in a sustainable way, Togo will need to have access to more sustainable energy sources to provide the whole population with access to electricity. Jacobs (2014) reports on the needs of people in Togo and how these are addressed by NGO Solar Zonder Grenzen (Jacobs, 2014), according to the interviewee who works there on an energy project. Solar Zonder Grenzen – a project of NGO BISZ (Bevordering van de Interculturele Samenwerking met het Zuiden) – aims at providing light to the poorest in Togo (Solar Zonder Grenzen, 2018; VZW BISZ, 2017). This is done by installing solar installations, which provide energy and by creating lamps out of calabash, a local plant in Togo (Jacobs, 2014). A comparable project, also connected to Solar Zonder Grenzen, is the project of Energy Kiosks. This start-up installs specialized solar systems on roofs of cabins and lets the users pay for their usage via text messages. Whenever they have paid a certain amount, they become the owner of the installation, which is approximately after three years (IPS, 2017). In Jacobs (2014) the interviewee sums up the three success factors, according to him, of the Solar Zonder Grenzen project. These success factors are also applicable on this master thesis project. First, it is important to only solve a problem when the local community experiences it as a problem. It happens rather often that NGOs arrive in African countries to solve problems, without taking into account the opinion of the local population and its demands. NGO SEA already experienced a few times projects that were not used in the long term, since the needs and demands of the local community were not brought into reality as they wished. An example of this is a windmill for a school in Senegal, which was installed but not used very long since they had to switch the batteries on and off when there was a breakdown (Broeders & Aerts, 2015). This first success factor counts therefore for most development projects in the South and not only for this project and the one of Solar Zonder Grenzen. Second is the need of light in Togo. Every evening, all year, night falls at 5.30 pm. If families do not have lights in their cabins, they have to sit in the dark for almost twelve hours each day. People try to solve this light problem by using petroleum lamps or Chinese lamps, which are very expensive and not sustainable. Third, most people have one or more mobile phones. Charging these mobile phones and using light in the cabin both demands energy and money. Solar Zonder Grenzen provides a sustainable solution by 1) providing solar kiosks, where people can come to charge mobile phones and by 2) providing lamps which can be borrowed (Jacobs, 2014). These lamps are cheaper than the current alternatives. Another important success factor, not mentioned in the article, is the cultural aspect. It happens quite often that this is not taken into account when considering the usage of energy, which can lead to the elimination of social activities that are important to the inhabitants. An example is some people that go for gas bottles together every week and talk and/or gossip all the way long about things that happened the past week. When they do not need to go for gas anymore, they will also lose this social interaction with each other and thus start going for gas bottles again just for these social reasons.

During the summer of 2017, I stayed in Togo for six weeks (40 days). There, I could experience the energy problems myself. I resided in the Sichem centre, which does have a connection to the electricity network. Still there were a lot of breakdowns, at least 20 over the course of 40 days. Some of them lasted a few minutes, 3 lasted for more than 14 hours. Also, every thunderstorm was followed by a breakdown. The average day at the office of Solar Zonder Grenzen (in Kpalimé) has 22 hours of electricity supply, but breakdowns of 7 hours are not rare (Jacobs, 2014). Since Sichem has the purpose of helping with the development of the surrounding villages and communities, it is important that it has a constant supply of electricity. When there is an education moment for cultivators for example, a breakdown will interfere with the schedule and might make it necessary to postpone the lessons to another day.

Translating the success factors of Jacobs (2014) for Togo to Sichem specifically leads to the following three steps that will be addressed in this master thesis. First, we have to know the needs, demands and expectations of Sichem itself and the surrounding villages and communities. Second, an add-on has to be found that is strong enough to ensure a long term use of the solar installation. Third, this add-on needs to be managed in the right way and therefore needs a structured and well considered business model. Thus, an answer must be found for three questions: what are the needs, which add-on is strong enough and how can it be managed? These questions are specified more precisely below. To answer these questions, I went to Sichem, leaving the 10th of July 2017 and returning the 20th of August. During these six weeks, I did a local analysis by talking to the people, by looking at their habits and culture and by conducting a questionnaire. This led to three different energy innovations – three different powerbanks – proposed to the local community, of which one was eventually selected and for which a business model was developed.

The main research question is as follows: "Which business model for the locally selected powerbank will provide the local population of the Sichem centre in Dzogblakopé, Lomé, Togo with energy in a sustainable way?"

The first subquestion handles the *current* situation of energy usage, for both the applications and the costs in Sichem and the surrounding villages. The second subquestion is about the *characteristics* of the solar installation itself and the add-on. The third question is about the *willingness to pay* (WTP) for the powerbanks. After having chosen among the different options and having calculated the WTP, we continue to develop a general *business model* for the powerbank, which will guarantee long term usage of the energy installation. With sustainable in the main question different things are meant. First, there is aimed at a long term usage of the energy installation. Second, the energy installation is a renewable one with solar panels. Third, the business model will be developed with the lowest environmental and social impact possible.

2.1 Subquestion 1

The first question is: "What are the current costs and applications of energy for both the Sichem centre and the surrounding villages?"

This question has the purpose of getting an impression of the global situation of the centre: which different types of energy are used, like carbon, electricity and gas, which devices are used such as mobile phones, lighting and televisions and what are the costs of the energy consumption. These numbers will give a better view on which energy sources are most important, what kind of energy installation is preferred and what kind of energy innovation will be useful for the villages. Information on costs is gathered by Antoine Dzamah, the head of Sichem. Information about the applications that are being used, is obtained by observing the different devices while visiting people and places.

2.2 Subquestion 2

Subquestion two is: "Which characteristics are the most important for the solar installation and the powerbanks?"

The installation exists of solar panels combined with batteries to store the generated energy and can only be used during electricity breakdowns. The add-on is a powerbank which is charged using the net and thus only when no breakdown occurs. To find out which characteristics are the most important, a quantitative research is needed. On the one hand, I talk to the people in Sichem about the culture that rules in the centre concerning energy provision, so no social activities are deleted without knowing. On the other hand, the characteristics of the solar installation and powerbanks should also be taken into account, such as the transportability, since this can increase the acceptance and usage.

2.3 Subquestion 3

Subquestion three: "What is the *willingness to* pay (WTP) for the powerbanks?"

To answer this question, three different stages need to be passed through. The first one is "preparing the questionnaire". This includes decision making on the methods for asking the questions, the correct sample size and the formulation of questions. The second important stage is "conducting the questionnaire". This stage is about the ways in which the households are chosen and the questions are asked. The third stage is "analysing the data". Here, the gathered data are used to calculate the WTP for each powerbank, choose one option and look for influences on WTP.

2.4 Subquestion 4

The fourth subquestion: "Which business model is the best guarantee for a sustainable use of the chosen powerbank?"

For this subquestion, a business model is developed for one type of powerbank that is chosen as the most promising one. The different attributes such as costs, benefits and prices will be treated in this model and also the sustainability is taken into account.

3 Current energy usage

The first subquestion is: "What are the current costs and applications of energy for both the Sichem centre and the surrounding villages?" This question has the purpose of finding out how much energy is currently used in the centre and how much it costs. Also the different electronic devices or other usages of energy are considered. The same is done for the households in the different surrounding villages, despite the difficulties concerning the costs.

3.1 Sichem

First, all the things mentioned above are analysed for the Sichem centre itself.

3.1.1 Use

In Sichem, many different energy applications and electronic devices are found. First, electricity is used for the lighting in all the buildings. Further, Wi-Fi is created, which demands electricity as well. Sichem has a sewing atelier and those machines work with electricity, as well as the kitchen in Sichem, the butchery and the production of syrups. Sometimes electricity is replaced by the use of carbon or wood, for example for frying potatoes. The households on the site of Sichem also use a lot of wood to make fires in order to cook meals in a pot above the fire. The most used energy forms are therefore electricity itself as well as carbon and wood. In some places, gas is also an alternative, but in Sichem, this is used less than the other forms.

The different devices used in Sichem are lights, fridges, freezers, stoves, computers, beamers, printer, mobile phones, ventilators, Wi-Fi routers, a washing machine, sewing machines et cetera.

3.1.2 Costs and quantity

The electricity is measured by two different meters. Antoine Dzamah explained that the electricity prices stay more or less constant through the years (personal communication, 13 July, 2017). In Togo, the price depends on how much kWh is consumed – a system with tranches – and is always invoiced per month. For the first 200 kWh it is a fixed tariff (84 CFA/kWh), for the next 150 kWh it is a higher tariff (114 CFA/kWh) and thereafter it costs 120 CFA/kWh ("Facture d'energie basse tension," 2017). For Sichem, it is therefore better to have multiple meters, since this enables them to consume more kWh at the lowest tariff. The costs of electricity from 2014 to mid-2017 are listed in table 1. The total cost of electricity increases every year. In 2016 for example, the costs were three times as high as in 2014, and during the first six months of 2017, there is already a higher cost than in 2015. Since the prices per kWh are approximately fixed, this must be due to increased consumption. Table 1 further indicates how much electricity is used. These quantities are calculated based on the total costs and prices of each tranche. In 2016, 3 times as much electricity was used as in 2014, which confirms the statement above. The quantity rises every year and thus it can be stated that electricity becomes more and more important for Sichem.

Table 1: Costs and quantities of electricity in Sichem (2014 to mid-2017)

Year	Costs	Quantities
2014	560,095 CFA	5,608 kWh
2015	1,205,674 CFA	11,584 kWh
2016	1,800,129 CFA	16,599 kWh
Mid-2017	1,251,289 CFA	11,237 kWh

The costs of gas, carbon (of wood) and wood are available for the years 2014 to mid-2017, which is represented in table 2. The numbers indicate that the total cost of these three energy sources decreases over the years. Since prices per unit did not decrease much, one can conclude that less gas, wood and carbon is used.

Table 2: Costs of gas, wood and carbon (2014 to mid-2017)

Year	Costs of gas, wood and carbon
2014	144,900 CFA
2015	141,900 CFA
2016	119,000 CFA
Mid-2017	66,000 CFA

3.2 The surrounding villages

The same things are analysed for five surrounding villages that are taken into account for this research. Since it was rather difficult to take into account every household in every village, I tried to notice as much as possible, which enables me now to give a general impression of the use, quantity and costs of energy in the villages. The surrounding villages were studied for the add-on that will be introduced. As stated above, the add-on is a powerbank, which will be introduced to the villages in order to give Sichem the opportunity to gain some extra profits. Therefore, it is important to study the energy usage and costs of the villages as well.

3.2.1 Use

In the villages, only a few households have access to the electricity network. However, these households cannot rely on it, since it has many breakdowns. Therefore, electricity is not used within the houses itself in general. Most households use wood to make a fire in order to prepare meals. This also provides some light in the dark. Flashlights and radios are also common, which work mostly on batteries. Since almost everyone possesses a mobile phone, they need to be charged as well. This happens with an electricity source somewhere in the village (at a kiosk or at someone's place in the village). A minority of people in the villages possess a generator, which enables to use devices such as television, radio and ventilators. Small portable solar panels were also noticed, connected to *powerbanks* to store the produced energy or just as a source to charge mobile phones directly. In the villages, the most used energy form is therefore wood and some other forms are used such as carbon, batteries, electricity from a generator or small solar panels.

3.2.2 Costs and quantity

Since most households use wood, it is rather difficult to evaluate how much costs they have. This wood is not always bought and the households do not register how many times they buy wood each month and for how much. I was not able to gather information concerning how much households spend on energy (for wood, carbon, gas and maybe even petroleum). One woman in one of villages (Dzogblakopé) told me some prices of batteries. According to her, a flashlight cost between 500 CFA and 1,500 CFA, depending on the size. Most flashlights need two big batteries inside (like the types C or D), which costs around 100 CFA each (Anonymous, personal communication, 21 July, 2017). This woman also said that these batteries last for 5 days and after that, they need replacement. On a monthly basis, this would induce a cost of 1,200 CFA. The article of Jacobs (2014) about NGO Solar Zonder Grenzen, states that mostly Chinese flashlights are used by the people and that these batteries cost approximately 1,500 CFA each month (Jacobs, 2014). Also, it is claimed that these flashlights do not have a very good quality and already break down after four months (Jacobs, 2014). This price is close to the prices I perceived. The difference can be due to negotiations of the price for example. In Togo, there are not many fixed prices and almost everything needs to be bargained. If someone has a connection or has better skills, the prices will be lower than for someone else, even for exactly the same product. Jacobs (2014) also states that petroleum lamps cost 2,000 CFA per 120 hours of light for only the petroleum itself. These lamps are really bad for the health of the users since they produce unhealthy vapours (Jacobs, 2014).

4 Important characteristics of the solar installation and the powerbanks

The second subquestion is: "Which characteristics are the most important for the solar installation and the powerbanks?" The first subquestion handled the broad view of the energy use, the devices used, the quantities and the costs accompanying it. The second question focuses on the social perspective of the use of energy. This means that we are focussing on which characteristics are the most important.

4.1 The solar installation

As explained in the introduction and problem statement, Sichem does not have a stable electricity access. Most of their activities demand energy usage, which makes it difficult for the centre to function properly when there is no electricity available. A new energy installation was therefore really important for the centre and enables Sichem to further deploy their activities. Nevertheless, not every installation is suitable for the centre. The installation needed to fulfil their needs and expectations and had to work properly. Moreover, some forms of energy usage bring along social interactions. An example is women who collect wood together and discuss the newest gossips on their way. Changing the type of energy usage could imply that there is no need anymore to collect wood and so there is also no opportunity anymore to gossip. This would delete the social activities that people create together. When people start missing these social interactions too much, they might start collecting wood again, just to have these interactions, which would decrease the chances of the new energy installation to be used in the long term.

The installation that was build, consists of six solar panels combined with four batteries to store the generated energy. Whenever there is a breakdown of the net, these batteries take over and provide the centre with the necessary energy supply. During the night for example these batteries enlighten "emergency lighting" so that the domain is not too dark, the chances of vandalism or theft are lower and thus the site of Sichem is safer. When no breakdown occurs, the system charges the four batteries. The centre only uses the batteries during a breakdown, so no energy is saved unfortunately. Since a single battery, like the four bought ones, is so expensive, it was impossible for the engineers to provide more. Therefore, the solar installation can only help to overcome a breakdown and not to save on energy costs. The energy innovation, a powerbank with different potential services, is charged using the electricity network. Whenever a breakdown occurs, these powerbanks cannot be charged anymore.

Like stated in chapter three, the most used energy form in the centre itself, is electricity. Before, people in Sichem used electricity when there was no breakdown and when there was a breakdown, they simply waited until the breakdown was over. When they needed wood or carbon, they used some that they found on the site itself or some wood was bought, but this also does not bring along different social activities. It can be concluded that the new energy installation does not eliminate social activities that are important to the inhabitants. For the centre, some important aspects needed to be taken into account when designing the installation itself. Antoine Dzamah, head of Sichem, and

Ria Etienne, member of Togo Debout and living in Lomé, already had experience with solar panel installations on the roof of one of their dispensaries (personal communication, 19 October, 2017). They do believe in the installations themselves, but the batteries that are used, break down very quickly (after one year for example) and are often overheated. Therefore, they demanded to make sure that the used batteries are compatible with the constant high temperatures and humidity in Togo. This was one of the most important aspects for them: they wanted the installation to work on the long term. Another important aspect that they mentioned was the education of the local people. If the installation was built without informing someone about the technical details, it would be impossible for the local people to repair the installation when it breaks down. The education can therefore help to ensure the long term usage of the installation, which is the best for all parties that work on this project.

4.2 The powerbanks

Since most people walk many kilometres to charge the battery of their mobile phones, the idea came of finding a solution for that problem. The chosen innovation is an external battery – a *powerbank* – that can help the households to charge mobile phones and maybe also lamps, radios and televisions. To find out exactly which powerbank would be introduced to the people, a questionnaire was constructed and the results of this questionnaire showed which type of powerbanks was preferred by the people. This innovation was sought to ensure that the energy installation in the Sichem centre is used on the long term, since it motivates the community to make some extra efforts. This powerbank will create surplus value for the centre and the people in the surrounding villages by creating extra profit for Sichem and at the same time further developing the villages close to Sichem.

In the villages, the most used energy source is wood. Wood is used for cooking and also for light in the evenings, so introducing the powerbank does not interfere with the current ways of cooking. However, for charging mobile phones, people walk several kilometres, which brings along some form of social activities since people walk and talk together. Introducing the new powerbanks could delete some of these social activities, which decreases the possible usage of it.

To find out which **aspects** were important for the people in the villages, I went to some neighbouring households of Sichem and **interviewed** them about the purpose of the powerbanks and what they thought about it.

Just like Antoine and Ria mentioned, the battery problem also arose at the level of the inhabitants. Since some people already had experience with powerbanks and indicated that most powerbanks broke down rather quickly, it was important to take into account the **quality** of these batteries. Some households also mentioned that powerbanks have to be quite solid. Most households exist of five or more people and many people are walking in and out of the cabins all the time, so the chance that the powerbank falls sooner or later is rather high. Therefore the powerbank did not only need to have a good quality, but also needed to be solid enough to survive rough treatment. Another aspect mentioned by them was the **compatibility** of the powerbanks with their phones. Some people have rather old (dumb)phones, while others have the newest smartphones. It is thus important that the provided cables are for new phones as well as old ones. Another really important aspect that could make or break the powerbanks, was the **price** at which it is offered. In Togo most people do not have enough money or do not have the reflex to save (Jacobs, 2014). If the price is too high, the people who need it the most, will not be able to buy or rent these powerbanks. It was thus important to choose a correct price but also to try to keep this price as low as possible to enable the people to use this powerbank. For families it is best if the powerbank has a high **capacity** and can charge enough mobile phones and maybe even lamps, radios et cetera. However, it is important that the capacity is not too big, since this would increase the price without being useful for the people. Some households only have dumbphones which last for two weeks without charging. Nonetheless, there are also households that only have smartphones, which last for two or three days without charging. This means that these households also have a different demand for powerbanks and not all households have the same needs. It was therefore important to choose a capacity that was satisfying for most households or to develop powerbanks with different capacities in order to meet the needs of the households more closely. Lastly, since it is a powerbank that the households need to transport, it needed to be **transportable**: not too heavy, unhandy or big to carry. This lowers the barriers to buy or rent a powerbank since the extra efforts are reduced to the minimum. Since these powerbanks only replace the displacements made for charging mobile phones, it does not interfere with possible social activities accompanying the gathering of e.g. wood, but might interfere with the social interactions of charging mobile phones together.

Three different powerbank options were developed, which were proposed to the households through a **questionnaire**. The first option was a powerbank that can charge mobile phones and lamps. When fully charged, the powerbank can charge up to 100 mobile phones before being completely discharged. However, when also lamps are used, the capacity of the powerbank equals 50 charges of a mobile phone and light for two weeks. Furthermore, the powerbank is compatible with all sorts of phones. The second option was a powerbank that can charge mobile phones and lamps, but also a radio. This option has the same capacity as the first powerbank, but the amount of phone charges will depend on the usage of the radio and lamps. The third and last option was a powerbank that can feed a television during one month. With this option it is thus impossible to use lamps, power a radio and charge mobile phones. The exact description of the powerbanks as presented to the interviewees as well as the complete questionnaire, can be found in appendix 1. This was written in French, since the Togolese population knows French as an official language.

In the questionnaire, different **advantages and disadvantages** were asked regarding the first powerbank presented. Most people indicated that the most interesting advantage of these powerbanks would be that it ensured them to always have a charged mobile phone as well as light in their cabin. The least interesting advantage was that everyone at home can use it. The most important disadvantage of these powerbanks, according to the respondents, was the risk of breaking due to imprudence. The other disadvantages were all chosen by some respondents to be (the least) interesting so no disadvantage sticks out. The reliability of these results is looked at more closely in chapter 5 (data description). The different (dis)advantages can be found in the questionnaire itself in appendix 1.

4.3 Conclusion

It can be concluded that both the solar installation and the powerbanks needed to be of good quality, especially the batteries. The powerbanks further needed to be correct in terms of price, transportability and compatibility. These aspects are quite the same as the aspects considered in Belgium when buying powerbanks. Three different powerbank types were proposed and one was selected based on the results of the questionnaire.

5 Data collection through questionnaires

This chapter provides details on the used methods, the formulation of the questions, the sample, the conducting of the questionnaire and the collected data. Chapter 6 will go into further detail of the data analysis and conclusions made based on this data.

5.1 Preparing the questionnaire

Preparing the questionnaire comprised choosing a method for the construction of the questions, defining a sample size and formulating the questions.

5.1.1 Double-bounded dichotomous choice method

In order to prepare the questionnaire, a specific method needed to be chosen for the WTP. For this master thesis, the *double-bounded dichotomous choice* (DB-DC) method was chosen, since it was the most applicable method for this kind of research: the advantages (e.g. creating real-life situation) outweighed the disadvantages (e.g. large sample needed). Below, the different advantages and disadvantages are explained, which makes it clearer why this method was preferred.

The DB-DC method is a specific form of *contingent valuation* (CV), which is a form of *stated preference*. Stated preference means that people are not revealing how much they are willing to spend, but they are telling it. With contingent valuation, people are asked directly to state their WTP (Lopez-Feldman, 2012; McLeod & Bergland, 1999) and it is most widely used to estimate nonmarket values (Donfouet, Jeanty, & Mahieu, 2014), which are goods or services not traded in the marketplace (Bradford, Kleit, Krousel-Wood, & Re, 2004). CV methods are being used more often in developing countries to discover the individuals' preferences for infrastructural projects like sanitation or for environmental economics (Venkatachalam, 2004). Using the dichotomous choice method, people are asked whether or not they are willing to pay a specified amount of money (Calia & Strazzera, 2000; Jeanty, Haab, & Hitzhusen, 2007; Veronesi, Alberini, & Cooper, 2011). The bid can be accepted or rejected by answering "yes" or "no" to the question. Since there is only one question being asked, this method is called the *single-bounded dichotomous choice* method. When the *double-bounded dichotomous choice method* is used, a second question is asked. Dichotomous means that a "Yes or No"-question is posed and double-bounded means that two questions are asked so that the WTP is limited by two bounds (Bradford et al., 2004). The second question is the same as the first, except for the amount of money. This amount is lower, respectively higher, than the first amount when the answer to the first question is "no", respectively "yes" (Bradford et al., 2004; Cai, Deilami, & Train, 1998; Hanemann, Loomis, & Kanninen, 1991). This question can thus be seen as a follow-up question depending on the response to the first question (McLeod & Bergland, 1999), which is the reason why the method is sometimes called the *take-it-or-leave-it-with-follow-up* (Venkatachalam, 2004) or the *dichotomous-choice-with-follow-up* (Cameron & Quiggin, 1994). That way, it gives more precise bounds to the WTP than the single-bounded method (Bradford et al., 2004). Although one might expect that more follow-up questions will result in higher efficiency, this is not true. A third follow-up question for example produces a small gain in efficiency while it induces more inconsistencies (Yoo & Kwak, 2009). Therefore, the double-bounded dichotomous choice method is chosen for this research, since it gives a better result than the single-bounded (Zografakis et al., 2010) or third-or-more-bounded method (Venkatachalam, 2004). Based on the responses given, a WTP can be estimated using econometric methods (Zografakis et al., 2010), like the *doubleb method* in STATA (Hanemann et al., 1991; Lopez-Feldman, 2010).

Advantages. Using the DB-DC method, people are faced with a decision that arrives frequently in their everyday life, namely "should I buy it or not" (Jeanty et al., 2007). Therefore, the valuation questions are very understandable for the respondents, cognitively less challenging (Jeanty et al., 2007) and the response distortions are kept to the minimum (Calia & Strazzera, 2000). Cai et al. (1998) state that this is easier than a multi-attribute choice experiment since only one thing is changing at a time (Cai et al., 1998). Furthermore, they state that this manner of asking questions makes it possible to call respondents for an interview, which is not possible with choice experiments for example. Like stated above, the DB-DC method has more precise boundaries than the *single-bounded* method, which is also an advantage of this method (Bradford et al., 2004). Calia and Strazzera (2000) even state that double-bounded is always more efficient than the single-bounded, since the double-bounded method has smaller standard deviations (Calia & Strazzera, 2000).

Criticism. According to Jeanty et al. (2007), the DB-DC method is criticised due to a lack of behavioural and statistical consistencies between the first and the second question. For the first question, it is possible that the respondent is rather sure about their WTP. However, when the second bid is proposed, the respondent is likely to be influenced and start to doubt the initial valuation. This can lead to behavioural (internal) inconsistencies between the two questions (Jeanty et al., 2007). Stated differently, this means that the respondent answers the second question with a different referential value in mind comparing to the first question, since the initial value is "updated" after the second bid (McLeod & Bergland, 1999). These internal inconsistencies are mainly arising from the second response (Donfouet et al., 2014). Sometimes, the respondent starts to doubt the nature and quality of the good or service after the second bid and will therefore be unable to give a second answer that reflects their true valuation (Jeanty et al., 2007). But despite this potential bias, the method is still used frequently since the second question narrows down the confidence interval of the WTP, which leads to more precise estimations and thus an increase in the efficiency of the contingent valuation model (Jeanty et al., 2007). Other researchers also state that not only the second but also the first bid can cause the respondent to be influenced by the height of the bid and is therefore likely to update the initial WTP (Calia & Strazzera, 2000; Czajkowski, 2007; McLeod & Bergland, 1999), which is called *starting-point bias*. This bias is also known as *anchoring bias* since the respondent anchors the valuation based on the available information, for example because they are not sure about the value they place on it (Veronesi et al., 2011). According to them, this "anchoring" can also happen between the two bids and cause internal inconsistencies, like stated above. To minimize this bias, the initial bid could be pretested in order to have a bid in the middle of the distribution. Bradford et al. (2004) state that this bias can also be reduced by randomly varying the initial bid round a predetermined mean, among the different respondents (Bradford et al., 2004). Another disadvantage of the DB-DC method is the *yeah-saying effect*, which means that the respondent is saying "yes" to the first or second bid, even though their true answer should be "no". An explanation is that the respondent has to answer immediately and does not have the chance to evaluate it (Calia & Strazzera, 2000). Czajkowski (2007) warns for respondents acting strategically towards the second bid (Czajkowski, 2007). Mostly, respondents will answer truthfully to the first question, but answer strategically to the second in order to achieve a more desirable result (Donfouet et al., 2014). An example of *strategic behaviour* is when people say "no" to the second bid hoping to lower the price of this good or service. Another example of the strategic bias is when people say "yes" to the second bid so that the good or service will be provided for sure, even though they are not willing to pay that much for it. Since with this method little information is gathered from each respondent, a large sample is needed to arrive at a decent level of accuracy (Cameron & Quiggin, 1994; Jeanty et al., 2007).

5.1.2 Sample

Like stated above, the DB-DC method creates the necessity of a big sample size (Jeanty et al., 2007; Venkatachalam, 2004). The sample sizes of some executed surveys differ much. Sample sizes of 126 respondents (Bradford et al., 2004), 369 households (Donfouet et al., 2014), 623 respondents (McLeod & Bergland, 1999), 636 usable respondents (Jeanty et al., 2007), 800 respondents (Yoo & Kwak, 2009), 1,000 respondents (Czajkowski, 2007; Veronesi et al., 2011), 1,013 respondents (Cameron & Quiggin, 1994) and even 1,235 respondents (Zografakis et al., 2010) are found.

Calia and Strazzera (2000) used multiple sample sizes in their research to compare and look for differences between the efficiency of single-bounded and the double-bounded method. They used sample sizes of 100, 250, 400 and 1,000 respondents. It showed a big difference between a sample of 100 and 250 respondents. When an even bigger sample is chosen (400 or 1,000), the difference becomes negligible. The double-bounded method has thus a higher efficiency when a small sample size is chosen, but the differences becomes smaller when the sample size increases, with a cut-off value of 250 respondents (Calia & Strazzera, 2000). Hanemann et al. (1991) also state that, although the single-bounded method is easier on the respondent, it leads to less efficiency (comparing to the DB-DC method) and needs a larger sample to attain a certain precision.

With this information about sample size, an ideal size of 250 was chosen. This size was aimed at when going around in the villages. Whenever possible to query more households, this opportunity was taken in order to have an even larger sample and attain a higher level of precision. The target group queried, were households in the surrounding villages around Sichem and also the households living on the site of Sichem itself.

The sample selection is an important aspect that influences the unbiasedness of the data and therefore also the reliability, validity and precision. A sample can never be an exact replica of the population, but it can be fairly close (Sekaran & Bougie, 2013). The best way to select respondents is by hazard. Therefore, the survey team always started in the middle of the village (at the house of the village chief), split up and went further until the end of the village in a random way. The characteristics of the needed persons for the survey were people at home, with enough knowledge of the usage and costs of energy, the income of the family and more information like that. So, when walking through a village, the houses with people present were selected and the one at home with the most knowledge was chosen to participate. By doing this, the selection was random since no fixed rules were specified such as "always take the right turn" or "always leave one house between selected houses". The five villages were selected based on their proximity to and collaboration with Sichem. The survey was closed after attaining 347 usable answers.

Despite the random selection of the respondents, it is possible that some amount of sample bias is present, since it is always possible to conduct a survey in a more random way. An example could be by using predefined random numbers to choose a house, street etcetera. Another possible bias is that "the one at home" is always the respondent even though it might not be the one with the most accurate information to answer the questions, which could slightly reduce the data quality. The one at home is usually not the head of the household and therefore the answers influenced most by the lack of information are about the head of household, the revenues of the family and the costs they are making for energy. This way of sample selection introduces a small amount of sample bias and measurement error, but is reduced to the minimum by trying to select in a random way.

5.1.3 Formulation of questions

After choosing a method for the valuation questions, the questionnaire was constructed and formulated. I started with formulating the questions already before I travelled to Togo in order to have a starting point. During the first three and a half weeks I adapted the questions, changed almost everything and did a few pre-tests. Yoo and Kwak (2009) state that it is very important that the questionnaire contains a scenario that offers the respondent enough information about the different characteristics of the good – powerbanks in this case – so that it creates a context that is meaningful and understandable. This is the main reason why I did some pre-tests in Sichem and with some surrounding households.

The initial idea was to query households about two different energy innovations: 1) a small powerbank that could charge lamps and mobile phones and 2) a bigger powerbank for constructing a kiosk that could also charge lamps and mobile phones. Different advantages and disadvantages were listed to be demanded for each powerbank. The questionnaire also contained a "shock" for the valuation of the powerbanks. This means that the respondent would be asked to value the first powerbank, then was given extra information (a shock) and then would be demanded to value the powerbank again. After the first and second pre-test, it showed that the questionnaire was too long and that the second powerbank's capacity was too big for most people. Another remark was that no difference in valuation before and after the shock could be found. Also, most people demanded if it was possible to power a radio or maybe even a television, since this would be really helpful for them. After these tests, I started adapting these questions, eliminating quite a lot and brainstormed about new powerbank types which would form a better answer to the needs of the households. The result of this was a questionnaire with three different powerbank options. The first option is a powerbank that can charge mobile phones and lamps. The second option can power also radios and the third can only charge a television. I also decided to no longer demand the different (dis)advantages for every option since this was time-consuming, and the shock was also left out since there was no added value.

The questionnaire started with an *introduction*, followed by three different parts ending with the possibility to give remarks and a word of thanks. In the introduction, the purpose of this master thesis and questionnaire was explained. Furthermore, it was emphasised that all the responses are treated anonymous and confidentially. The *first* part was about the respondent, his or her identification, the identification of the head of the household and also the profession of the people within the household. Some examples of things demanded are: name, sex, age, job and head of household's information. This information made it possible afterwards to evaluate if there are differences in answers between certain groups. The *second* part tackled the utilisation of electronic devices. The respondent was demanded if mobile phones, lamps, a television, a generator … are used within the household. Other questions relate to the manner and price of charging mobile phones or the lack of possibilities to charge mobile phones. This part had the purpose of looking at the current habits of the people, their attitude towards energy innovations et cetera. In the *third* part, the three different options were presented one by one, followed by the valuation questions based on the DB-DC method. For the majority of the people, this was the most difficult part since they were asked multiple times to valuate situations they do not know in real life. For the first option, (dis)advantages were listed as well in order to have more detailed information about the important features the powerbanks should have. *Lastly*, the questionnaire ended with a word of thanks to the respondent who answered all the questions. Some space was foreseen to write down comments and remarks of respondents at the end of the survey. The complete questionnaire can be found in appendix 1.

In the beginning, a Likert scale was used for the questions concerning the attitude of the respondents. A Likert scale goes from 1 to 5, with 1 meaning "I totally not agree" and 5 "I totally agree". The respondent could choose the numbers from 1 to 5 to state to which extent he/she agrees with the statement (Sekaran & Bougie, 2013). Since this is a rather cognitively challenging manner, the questions were changed and posed differently. The final questions were all formulated so that they could be answered on a nominal scale. That is a scale which works with different categories like man/women, mobile phone/no mobile phone… This is easier for the respondent and gives me enough information for this research. Other questions were formulated as open questions, such as the name and the age of a person. This means that no pre-determined categories were specified and the respondent can answer just like that (Sekaran & Bougie, 2013).

As can be seen in Appendix 1, the questionnaire was written in French, since Togo has French as an official language. Nonetheless, the local inhabitants did not always understand and/or speak French themselves, which made it necessary to find people to translate it in Ewe, one of the local languages they speak in the South.

The survey was conducted with tablets and not on paper, which saved quite some trees and time afterwards. Since the questionnaire was conducted with tablets a good, safe and offline software program was needed that could fulfil these wishes. SurveyCTO was selected as software program since it is a software developed to collect high-quality data offline and keep it safe (Dobility Inc., 2017). The complete questionnaire needed to be programmed in this software, which then had to be installed on the five different tablets I had with me in Togo. Once the questionnaire was completed, programmed and installed on the tablets, it could be conducted in the villages.

5.2 Conducting the questionnaire

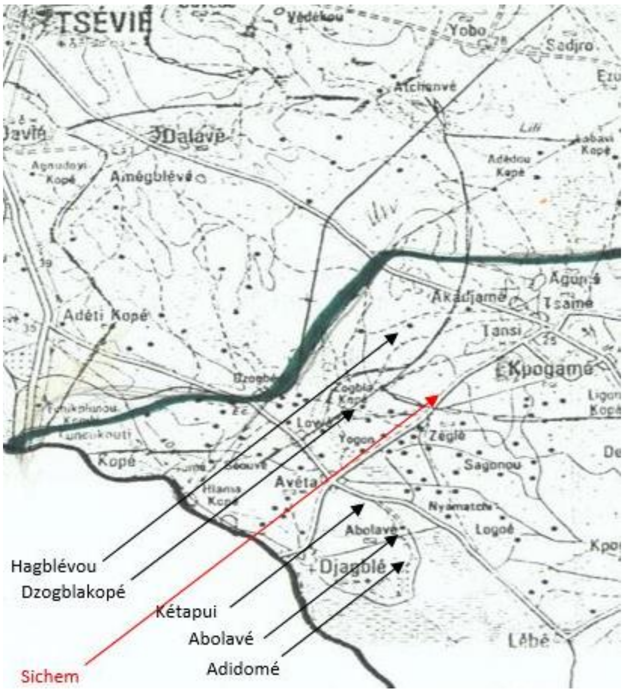

Figure 2: Map of Sichem and environment with all the visited villages marked

The survey was conducted through a structured interview, face-to-face, in Sichem and 5 surrounding villages, indicated on figure 2, during the week of 7 to 11 august 2017. The 7th we visited Dzogblakopé, the 8th Hagblévou, the 9th Kétapui, the 10th Abolavé and the 11th Adidomé. A structured interview means that a predetermined order is followed during every interview in order to keep the possible order-bias as low as possible for every interview (Sekaran & Bougie, 2013). Face-to-face interviews are said to lead to high data quality in terms of completeness for example (Yoo & Kwak, 2009), which is an important advantage and one of the reasons this method was chosen. The other reasons are also rather obvious since telephone interviews are difficult in Togo and spreading the questionnaire over internet is not possible. These surveys were conducted with tablets and not on paper, like stated above and therefore, it is important that the questions are read in an objective manner without influencing the respondent. More specifically, a *personally administered questionnaire* will be used. The biggest advantage of this method is that possible ambiguousness or obscurities can immediately be solved, which leads to less bias caused by wrongly interpreted questions. At the same time, this method can lead to more bias since this extra information or the manner of posing questions can influence respondents (Sekaran & Bougie, 2013).

In order to attain a sample size of at least 250 households, I decided to hire five students to help me conducting the questionnaire. These five students were selected by Arsène Attidokpo, my local supervisor in Sichem, and all spoke French and Ewe. To make sure they knew how to conduct a questionnaire and understood the purpose of the questionnaire and all the questions itself, I organised a formation of two days. The first day, I explained the broad context of my master thesis, the purpose and aims of it and the importance of the questionnaire to achieve these aims. Further, I explained them how to behave as an interviewer, how to pose questions in a neutral way, how not to judge about the respondents or give answers in their place. Since these aspects are very important to avoid bias, I made a manual for the students, which can be found in Appendix 2. In this manual it is explained, with examples, how to be a good interviewer. Lastly, I gave more information about the meaning of every question, every note and every explanation. Together with Arsène and Eugénie, the students translated the questions to Ewe, while keeping the correct interpretations. The second day of the formation, I taught them how to work with the tablets and how SurveyCTO works. Around noon, we were ready to do some tests in "Sichem I", "Sichem II" and "mon refuge". Sichem I is a little hamlet next to the centre, Sichem II is the site of the centre itself and Mon Refuge is another hamlet close to the orphanage ANGE, which is also close to Sichem II. After these – successful – tests, we were ready to start the "real" questionnaire on Monday the 7th of August.

The week passed rather quickly since we were all very busy conducting questionnaires, walking around in the villages and looking around to find people to interview. The team – me, the five students and Eugénie – had a good collaboration and the atmosphere was pleasant. After this one week, we succeeded at conducting 347 useful questionnaires. Some general impressions of my survey team and the manner of working, can be seen on the pictures below. (Everyone in the pictures agreed on the use of them for my master thesis.)

Figure 3: Picture of an interviewer and an interviewee (1)

Figure 4: Picture of the whole team (Pierre, Paul, me, Assouppi, Bertine, Sandrin and Eugénie)

Figure 5: Picture of an interviewer and an interviewee (2)

My local supervisor handed me some information concerning the population of the villages around Sichem. For three of the five villages, the amount of inhabitants was counted and reported by him in this doctorate thesis (Attidokpo, 2016). These numbers are a minimum, so it is possible that it is an underestimation of the total amount of inhabitants. In Kétapui, 425 inhabitants (at least) were counted in 2010. In Abolavé and Hagblévou 347 and 234 inhabitants were counted, also in 2010. I did not succeed at collecting these numbers for the two other villages. However, Dzogblakopé, resp. Adidomé, is approximately of the same size as Kétapui, resp. Hagblévou. Therefore, it can be stated that Dzogblakopé has around 500 inhabitants and Adidomé 230 inhabitants. Togo knows a rather strong growth rate (2.64%). Therefore, it is expected that these numbers already increased by the time I arrived in the villages (summer of 2017). In Kétapui for example, a population of 510 could be expected and in Abolavé 416 inhabitants were expected to be found. In Dzogblakopé, 81 respondents were gathered. Taking into account that the average family has 5.50 members, 445 inhabitants were reached. For Hagblévou, 319 inhabitants were reached (or 58 respondents with an average family size of 5.5) even though only 281 inhabitants are expected. In Kétapui, Abolavé and Adidomé, 522 inhabitants (95 respondents), 418 inhabitants (76 respondents) and 165 inhabitants (30 respondents) were reached. Comparing this to the population registered in 2010 indicates that most of the families in the villages were queried. Therefore, this sample is a reliable representation of the population of the villages. The population numbers in these cities are also represented in table 3 below, together with the reached inhabitants. Comparing these numbers with the calculated reached inhabitants leads to the conclusion that the initial population numbers were an underestimation. Another possible but less likely explanation for the higher reached inhabitants is that the respondents overestimated the size of their family.

Table 3: Population of the villages

	2010	2017	Reached in 2017
Dzoblakopé	500	600.05	445
Habglévou	234	280.82	319
Kétapui	425	510.04	522
Abolavé	347	416.43	418
Adidomé	230	276.02	165

5.3 Data description

Once the survey was done, all the gathered data needed to be analysed through statistic and econometric techniques. In order to analyse this data correctly, a specific calculation method was chosen for the valuation questions, namely the *doubleb method* in STATA, a software tool that enables the use of statistic formulas. Since the engineering students already needed information quite early in order to design the installation, a quick data review and short analysis were already provided beginning of October 2017. In the following section, the general data description is given as well as some general statistics. The extended data analysis with the use of STATA is explained in chapter 6.

5.3.1 Description of data

The prepared questionnaire resulted in more than 50 variables. Some of them were not utterly useful in multiple ways, like location parameters or identification numbers of the respondents, but were necessary for the survey itself. In order to improve the understanding of the data analysis, a preliminary explanation of the different variables is presented. The variables were clustered together based on the different parts of the questionnaire.

Before the data was ready to be worked with, the **dataset** needed to be **cleaned**. The dataset contained 360 lines with information in the beginning. However, seven of these lines contained information that was useless for this research and were therefore erased from the dataset. Six other respondents were eliminated from the data set as well. The reason for five of these respondents is that the interviewers all filled in a questionnaire themselves in order to have a better idea of the different questions, the different answering options and the predetermined order of the questions. Since these surveys were not conducted by “real” respondents, they did not represent answers from households and were thus erased. The other erased respondent is the first pre-test I did myself in "nouveau Zéglé", a small village next to Sichem. After this pre-test, the survey changed almost completely and therefore does not represent the same as all the others, so it was decided to better leave this respondent out of the dataset. This leaves us with a database containing 347 useable respondents.

The first variables are **registration parameters**, like *starttime, endtime* and different location parameters. These give more information about the exact moment of registration and the exact location of the survey. These variables were not used for specific purposes in this analysis. The variable *duration*, with a maximum of 3,526 and a minimum of 153 seconds per survey, has a mean of 726.71, with a large standard deviation of 502.25. This shows that the survey once took only two minutes and a half, but at other times approximately an hour.

The first variables are all related to the **identification of the interviewee** (or *enquêté* in French) **and head of the household** (or *chef de ménage* in French), hereinafter CM. In total 16 different answers were given for the variable *PersonnesFamille* going from a family with only 1 person to families with 20. The mean is 5.50 person per household with a standard deviation of 2.60. The histogram in figure 6 represents the distribution of the given answers.

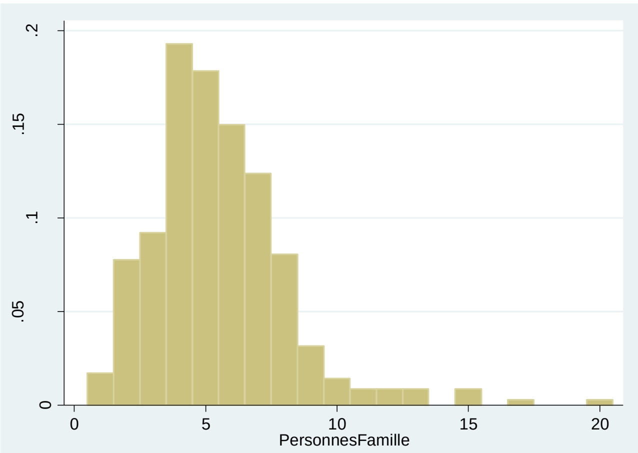

Figure 6: Histogram of the amount of family members (PersonneFamille)

Next are *NomPrenomEnquete* and *NomPrenomCM*, which stands for the last name and first name of the respondent himself and of the head of the household. The names needed to be written with the first name as normal and the last name in capitals. Another variable is *LeSexeEnquete,* which shows if the respondent is a man or a women, with 62% of the respondents being female. This variable has the value of 0 or 1 depending on the sex, with 1 for male and 0 female. The same goes for *LeSexeCM*, but here the sex of the CM is registered. In Togo, the CM is by definition male, so also in this questionnaire most of the household heads are male. The next variable that helps with the identification is *AgeEnquete*, which has a minimum of 15, maximum of 85, a mean of 39.36 and a standard deviation of 13.50. *AgeCM* is again the same for the CM. The variable *LienDeParenteCM* shows the connection or relationship of the respondent with the CM, such as mother/father, husband/wife et cetera. *PaimentNourritureEnquete*, resp. *PaimentNourritureCM,* indicates whether or not the respondent, resp. the CM, contributes to the payments of the food. The variables are both dummy variables, with 0 for no and 1 for yes. *TelephonePortableEnquete* indicates whether or not the respondent has a mobile phone, with a majority of roughly 85% respondents answering yes. The same goes for *TelephonePortableCM* where even a higher percentage is marked, namely 92%. Both variables are dummies, which means that they have only values of 0 and 1, with 0 for no and 1 for yes. *FormationCM* measures the education or training of the CM. This goes further than just ordinary schooling and can also be more practical formations. *TypeDeTravail* indicates whether the CM is doing a job 1) regularly, 2) independently or 3) occasionally. The variable *TravailExactCM* compromises the exact job of the CM. Two other variables, *TypeDeTravailAutre1* and *TravailExactAutre1* indicate the same, but for someone else in the household than the CM, for example the respondent him- or herself.

The next variables indicate more the **usage and utilisation of energy, electricity and electronic devices**. First, there are five (dummy) variables (*UtilisationAppareils_T_l_vision, UtilisationAppareils_Radio, UtilisationAppareils_Lampes, UtilisationAppareils_Frigo* and *UtilisationAppareils_Autre*) that show which electronic devices are being used by the respondent's household. These five options are: television, lights, radio, fridge and "other". Mobile phones are not included here, since they are already asked about in the introduction section. This shows that 31.41% uses a television, 74.35% uses a radio, 73.78% uses lights, 3.17% uses a fridge and 4.90% has also other devices, like a fan or a computer. *UtilisationAppareils* was the initial variable used to construct these different specific variables. Therefore, the others are more useful, since this variable has 18 different answers depending on the different combinations of electronic devices used by households. AutresAppareils comprises the different responses when someone indicated other devices were used in the household, so that the specifications are registered as well. Next, *AccesReseauElectrique* is a dummy variable that indicates whether or not the respondent has access to the electrical network. Furthermore, *Generateur* indicates whether the respondent possesses a generator, with the results of 0 for no and 1 for yes. If the answer was yes, two follow-up questions were asked concerning the costs. The variables *GenerateurCouteLuiMeme* and *GenerateurCouteConsommation* are both variables concerning those costs. The first one shows the cost of buying it and the latter one shows the costs of using it. This shows that the maximum cost of buying is about 1,000,000 CFA and that the cost of using it per week is maximum 30,000 CFA. Since these costs are very dissimilar and really high, it is possible that these numbers are not reliable, due to respondents without a clear view on their expenses.

The next variables are all related to **(manners of) charging the battery of mobile phones**. *CombienPortables* shows how many mobile phones are used within one household and was a necessary variable in order to verify if more questions related to mobile phone usage were relevant. If the respondent indicated there were no phones in the household, questions concerning how they charge it, would not give good results. This variable shows that there are households without mobile phones, but also households with 36 mobile phones, so there is a big difference between the different households. *MoyenRechargement* is the global variable used for the question which manner is used by the respondent to charge the mobile phone's battery. Since multiple manners were possible, this variable has 10 different combinations. Therefore, the following six generated variables indicate more precise if a specific charging method is used: *MoyenRechargement_ALaMaison, MoyenRechargement_Voisins_Amis, MoyenRechargement_QuelquunDeVill,* *MoyenRechargement_Kiosque, MoyenRechargement_AuTravail, and MoyenRechargement_Autre*. The first one implies that the battery is charged at home, the second one at the house of neighbours or friends, the third at someone's house in the village, the fourth at a kiosk, the fifth at work and the sixth indicates a different, not specified method. The most used method is at someone's place in the village (with 44.85%), then at a kiosk (30.61%), at friends (11.82%), at home (9.09%), at work (4.85%) and differently (0.3%). Since it is possible for the respondents to use multiple methods, these percentages do not sum up to 100. *AutreMoyenCharger* is another variable that registered the more specific responses of the other manners used. During this data gathering, there was only one respondent that indicated to use a different method for charging the phone. This manner was using the battery of the car for charging the battery of the mobile phone. *CombienFoisChargerAuKiosque* and *CombienFoisChargerAuVillage* indicate how many times per month the respondent goes to a kiosk or a person in the village to charge the phone. For both variables, 6 different options are possible: 1-2 times, 3-4 times, 5-6 times, 7-8 times, 9-10 times and more than 10 times. These variables do not have responses of everyone, but solely of the respondents that indicated they use that specific manner to charge their phone. *PrixRechargementKiosque* and *PrixRechargementAuVillage* are two variables that show how much the average person pays for charging the battery at a kiosk or at someone in the village. Both variables show that people pay at least 50 CFA and maximum 100 CFA. Since the averages are 66 and 71 CFA, the majority can be assumed to pay only 50 CFA. Looking a little bit closer into the details, it can be seen that 67.33% pays 50 CFA, 1 person or 0.99% pays 75 CFA and 31.68% pays 100 CFA at a kiosk. These percentages are similar to those at someone in the village: 57.43%, 0.68% and 41.89%. *CombienFoisBatteriePlate* indicates how many times per month the respondent has a dead battery caused by the lack of opportunity or money or … to charge the battery in time. This variable has 7 options, with the same as mentioned above and also an option "never".

The last series of variables relate to the different **powerbank options** that are presented to the respondents, which they are asked **to evaluate and value**. *AvantagePlusInteressant1, AvantageMoinsInteressant1, DesavantagePlusImportant1* and *DesavantageMoinsImportant1* are variables that show which of the different advantages, respectively disadvantages, were chosen as the most or least important. The first two variables have answers going from 1 to 5 and the last two from 1 up to 6. The following histograms (figure 7-10) show distributions of which answers were indicated the most. In chapter 4, it is already explained which advantages and disadvantages are the most, respectively the least, important. However, it needs to be remarked that these results might not be completely solid. It can be noticed for example that advantage 1 is indicated almost equally as much for both questions (most important and least important). One would expect the results not indicated as important in question 1, indicated as not important in question 2. Nonetheless, this pattern does not show. Therefore, it might be possible that the respondents did not correctly understand the questions and indicated twice what they see as important.

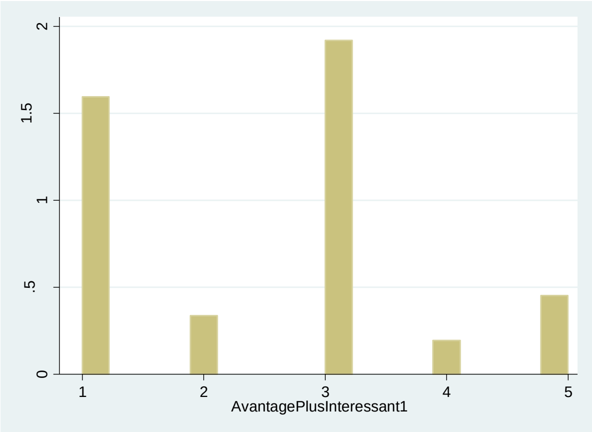

Figure 7: Histogram of the most important advantage

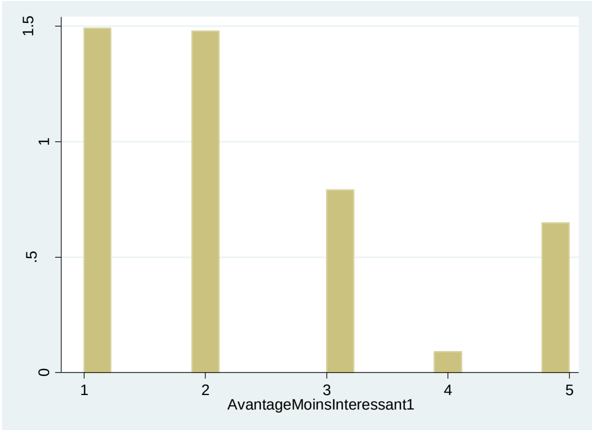

Figure 8: Histogram of the least important advantage

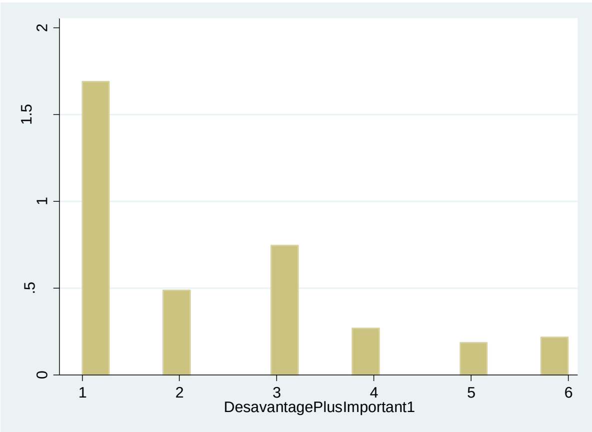

Figure 9: Histogram of the most important disadvantage

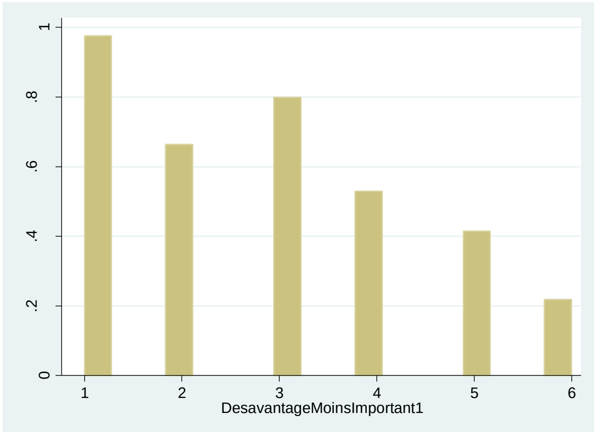

Figure 10: Histogram of the least important disadvantage

Prix1, Prix1PlusY, Prix1MoinsY, Prix2, Prix2PlusY, Prix2MoinsY, Prix3, Prix3PlusY and *Prix3MoinsY* are 9 different dummy variables which are related to each other. Every variable has the values of 0 or 1, representing the answers no and yes. The variables Prix1-2-3 indicate whether or not the respondent is willing to pay 3,500 CFA for the powerbank option 1, 2 or 3. If the respondent says yes to the first price, the second question pops up and variables Prix1-2-3PlusY indicate whether or not the respondent is also willing to pay 5,000 CFA. If the respondent indicates no to the first proposal, the variables Prix1-2-3MoinsY are used to register if the respondent is willing to pay 2,000 CFA.

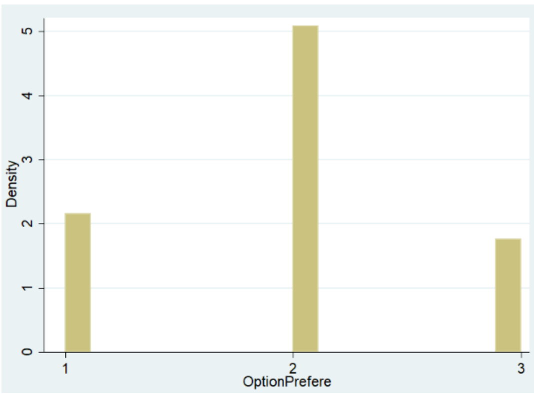

Figure 11: Histogram of the preferred option

OptionPrefere is the variable that indicates which option is indicated as preferred by the respondents. Therefore, 3 different responses are possible. Of the 347 respondents, 83 respondents or 23.92% preferred the first option (with the possibility of charging telephones and lamps), 196 or 56.48% the second (with the possibility of charging telephones, use lamps and power radios) and only 68 or 19.60% the third (with the possibility of using a television). This indicates that option 2 is the most wanted, followed by option 1 and lastly option 3.

Lastly, the variable *Remarques* is a variable that shows all the different remarks the respondents gave at the end. Some examples are "combine the 3 different options" or "the price should be 1,500 CFA". This variable was introduced in order to give the respondents the chance of giving some feedback or for the interviewers to write down interesting information that could only be seen or felt and was not possible to capture into the response to a question.

5.3.2 Correlations

The correlation table, which can be found in the appendix 3, shows how the different variables are related to each other and reveals possible hidden relations. The most important relationships are highlighted here. Table 10 shows that the amount of family members (*PersonneFamille*) is related to the first bids of the different powerbank types and also to the highest bid. These correlations are not very high. There is also a stronger (logical) positive relation between the amount of mobile phones and the amount of family members, which is significant on a 1% level. Another rather logic relation, is the positive relationship between the age of the interviewee and the age of the CM. This correlation is also significant on the 1% level and is rather strong (0.61). Furthermore, the age of the respondents shows a weak, but significant, relation with the different price variables. The variable that indicates if a television is used, shows significant relationships with the other variables that indicate the use of electronic devices. The different variables that indicate which manner is used to charge the battery of a mobile phone, show significant (1%) negative correlations with each other. The strongest negative correlation can be noticed between charging in the village itself and charging at a kiosk. This means that if someone charges at a kiosk, he will less likely charge at the village and vice versa. The same goes for the variables that indicate how often the battery of the mobile phone is dead and the price of the charging at a kiosk. The strongest relationships are between the price variables. Price 1 is strongly and significantly correlated with price 2 and price 3 and also price 2 and 3 are strongly correlated with each other. The same can be seen for price 1 ± Y, which is strongly correlated with price 2 ± Y and price 3 ± Y. Price 2 ± Y is also correlated with price 3 ± Y. The lack of correlation between the price variables and the preferred option is remarkable. That indicates possibly that the honest price does not reflect which powerbank the households prefer most.

The most relevant significant relationships are between 1) the amount of phones and the amount family members, 2) the age variables, 3) age variables and the price variables, 4) the variables concerning the charging methods, 5) all the price variables, which show the strongest correlations. It could thus be concluded that the significant relations found are also logical and thus the results have a good chance of being representative. These variables are tested in the next chapter to have an influence on the height of the WTP.

6 Willingness to pay for the powerbanks

The third subquestion is: "What is the *willingness to* pay (WTP) for the powerbanks?" In order to answer this question, three different steps need to be taken: preparing the questionnaire, conducting the questionnaire and analysing the gathered data. That way, a WTP estimation can be made and used in the business model of the last subquestion. The first two steps were already described in the previous chapter. This chapter covers the last step: analysing the gathered data. Chapter 5 only provided a description of the data as well as some general statistics. This chapter goes further into detail and calculates the WTP with the *doubleb* method.

6.1 Basic calculation of WTP

When the WTP is computed on a basic level, one can use the following equation.

$$WTP = \frac{\left(x_{yy} * (bid1 + Y) + \ x_{yn} * bid1 + \ x_{ny} * (bid1 - Y)\right)}{amount\ of\ respondents} \tag{1}$$

X_{yn} here indicates the amount of respondents that said yes to the first bid and no to the second bid. X_{yy} and x_{ny} therefore indicate the amount of people that said yes to both bids, respectively no to the first and yes to the second. Y indicates the amount with which the first bid is changed after the first answer. This means that all the lower bounds are used as the "real" WTP of the respondent. The actual WTP can be expected to be slightly higher, since not everyone has a WTP equal to the lower bound. If one applies this equation on the first option, a WTP of 3,553.31 CFA is found. The basic calculations of the other two options, together with the values of the different variables can be found in table 4.

Table 4: Basic WTP calculations

	x_{yy}	x_{yn}	x_{ny}	**WTP**
Option 1	130	122	78	3,553.31 CFA
Option 2	126	127	78	3,546.11 CFA
Option 3	129	116	77	3,472.62 CFA

Comparing the three options based on their preliminary WTP, a conclusion is made. The first option has the highest WTP, with only a slight difference with the second option. The third option has a somewhat lower WTP and is the least valuated method, based on these calculations. However, as stated above, the second option is chosen by more than fifty percent of the respondents and can be seen as the most popular powerbank type.

6.2 Calculation method doubleb

The method chosen to calculate the WTP is the *doubleb* method. This is a command developed by Lopez-Feldman in 2010 for STATA to calculate the willingness to pay for a certain good or service when the questions were posed using the double-bounded dichotomous choice method. However, this method is not an official STATA command. According to Lopez-Feldman (2010) this command uses maximum likelihood to calculate the WTP, just as Hanemann et al. (1991) describe in their work (Hanemann et al., 1991; Lopez-Feldman, 2010). The maximum likelihood (ML) procedure is an iterative procedure that tries to find the most likely estimates for the coefficients. Contrary to the least square method, where the sum of the squared differences between predicted and actual values is minimized, the ML procedure maximizes the likelihood that a specific event will occur (Hair, Black, Babin, & Anderson, 2014). This likelihood function can be transformed in a logged likelihood function, which has values from minus infinity to 0. The higher the logged likelihood value – or the closer to zero – the better, since this signifies better estimates.

Lopez-Feldman (2012) state that the WTP can be estimated by this linear function:

$$WTP_i(z_i, u_i) = z_i\beta + u_i \quad (2)$$

Z_i is a vector of explanatory variables, β of the parameters and u_i is an error term. When using the doubleb method, STATA calculates immediately β and without extra explanatory variables the WTP is simply a constant. When extra variables are added, an extra command is needed to calculate a WTP for the mean values for example (Lopez-Feldman, 2012; López-Feldman, 2013). Therefore, doubleb's output is at least one beta value and one sigma value. This sigma value can be left aside and is not needed in this research to calculate the WTP.

This method uses at least four different variables, needed specifically to estimate the WTP itself. These four variables are named bid1, bid2, response1 and response2 for simplicity reasons and are listed in table 5. The first variable (bid1) contains the value of the first bid itself. In this questionnaire it was decided not to use different bids so the first variable will equal 3,500 CFA for every respondent. The second bid variable (bid2) contains the value of the second bid proposed to the respondent. Again, since it was chosen not to use different start bids, this variable will only contain the values 2,000 CFA or 5,000 CFA. The value is 2,000 CFA, resp. 5,000 CFA, when the response to the first bid was no, resp. yes. The first response variable (response1) registers the answer to the first bid question and is therefore a dummy. The second response variable (response2) registers the answer to the second bid question and so is also a dummy. This variable comprises all the "second" answer, irrespectively of the answer to the first question.

Table 5: Meaning of variables doubleb method (López-Feldman, 2013)

Variable	**Definition**
Bid1	Initial amount proposed (3,500 CFA)
Bid2	Second amount proposed (2,000 or 5,000 CFA)
Response1	=1 when answer to first bid was yes, 0 otherwise
Response2	=1 when answer to second bid was yes, 0 otherwise

Even though a substantial amount of variables is already created, the price variables need to be transformed in order to be used for this command. Bid1 is easily made by creating a new variable that always equals 3,500. Bid2 is created by giving the values 2,000 and 5,000 depending on the answer to the first bid. The variable response1 is already known under another name, namely Prix1, Prix2 or Prix3. Lastly, response2 is created by combining the variables of Prix1/2/3-Y and Prix1/2/3+Y. Now, the WTP can be calculated. The command in STATA is: doubleb bid1 bid2 response1 response2 x1 x2 …. Calculating the WTP when extra variables are included can be done by using this command: nlcom (WTP: (_b[_cons] + x1_m*_b[x1] + x2_m*_b[x2])), noheader.

6.3 WTP calculation using doubleb

When calculating WTP without taking into account other variables that might have an influence, the results are higher than one would expect based on the preliminary basic calculations. For the first powerbank option, the WTP is 4,487.18 CFA, for the second 4,459.98 CFA and for the third 4,439.67 CFA, all significant on a 1% significance level. These WTPs are approximately 6.85 euro, 6.81 euro and 6.78 euro. An average wage at Sichem for example is 40,000 CFA per month, which puts these WTPs more in perspective. The difference between the different options is rather concise, since the biggest difference is only 50 CFA, which is approximately 8 euro cents. Moreover, when considering the confidence intervals of the three options, it is noticed that for each option the values of the other options are included in the confidence interval. Therefore, it can be stated that the difference between the options is negligible. Based on these WTP calculations, option 1 could be selected as the best option, since respondents are willing to pay the most for this option. However, option 2 is preferred by more than 50% of the respondents. Therefore, option 2 could also be considered as a promising option. Taking into account the preferences as well leads to the conclusion that powerbank 2 should be provided. This powerbank can be used to charge batteries of mobile phones, alight lamps and power radios. Furthermore, different factors were analysed that could be expected to have an influence on the height of the WTP. These extra influences were only sought for option two, since this option is the most promising. The different tested variables did not always have a significant impact on the height of the WTP. Therefore, they are listed below based on the result.

Comparing these WTPs with the prices of powerbanks in Togo gives a mixed result. According to the head of Sichem, the price of a powerbank is between 5,000 and 15,000 CFA, but the quality is rather bad since it has a Chinese origin (A. Dzamah, personal communication, 26 March, 2018). According to my local supervisor, the price of a powerbank amounts between 2,000 and 3,000 CFA (A. E. Y. Attidokpo, personal communication, 29 March, 2018). This is a huge difference and thus makes it difficult to make a conclusion. The prices of the head of Sichem indicate that the people are willing to pay less than what is currently on the market, so introducing a powerbank that is cheaper, can be really successful. However, the prices of my supervisor indicate that the people are already willing to pay enough to buy a powerbank and so the introduced powerbank will only be successful when the price is below 2,000 CFA. Given that not many people possessed powerbanks in the visited villages, it can be assumed that the numbers of the head of Sichem were more realistic. It is also possible that the prices of my supervisor are based on powerbanks with a lower capacity than the one that will be introduced, since this capacity is rather high.

6.3.1 Significant factors

The first analysed variable was *AgeEnquete* or the age of the respondent. This gives the following equation, which is significant on the 0.01 level.

$$WTP = 5{,}124.7 - 17.01795\ \times AgeEnquete \tag{3}$$

This signifies that the *willingness to pay* for someone of 20 years is 4,784.34 CFA, for someone of 40 years 4,443.98 CFA and for someone of 60 years 4,103.62 CFA. These numbers, just as the negative coefficient of AgeEnquete, indicate a negative relationship: the older the respondent, the less he or she is willing to pay for the powerbank. The constant of formula 3, or the WTP of someone with the age of 0, is rather high, but the minimum age among the respondents is 15, which immediately deducts approximately 250 CFA. This relationship is explained by the more intensive use of mobile phones by the younger generation. Younger respondents more often possess smartphones instead of dumbphones, like most "older" respondents. Smartphone batteries discharge faster, which causes the higher valuation of this powerbank by the younger respondents.

The next possible influencing factor was *PersonnesFamille*, which reflects the number of household members. This variable is significant on the 0.000 level and gives the following equation:

$$WTP = 3{,}648.219 + 147.6396\ \times PersonnesFamille \qquad (4)$$

A positive relationship is noted, so the more members in the household, the higher the indicated willingness to pay. For families of 2, 5 and 10, the WTP is 3,943.50 CFA, 4,386.42 CFA and 5,124.62 CFA.

Access to the electricity network is another potential important factor, with the following equation as result:

$$WTP = 4{,}411.757 + 776.7212\ \times AccesReseauElectrique \qquad (5)$$

Again, this indicates a positive relationship, so someone with access is willing to pay 776.72 CFA more than someone without access. This result is rather odd: one would expect a negative relationship since the powerbank and the electricity network form substitutes. Nonetheless, it might be possible that respondents with access are wealthier and so are willing to pay more for the powerbank even if the added value for them is lower. The same applies for having a generator. This variable has a positive relation with the WTP and thus having a generator increases the WTP with 548.71 CFA. The explanation here is that these respondents are wealthier when they possess a generator. Another explanation is that this powerbank fulfils the same needs as the generator, is cheaper and can thus be seen as a better alternative or investment with hence a higher valuation.

6.3.2 Insignificant factors

Many different factors were tested without finding a significant result. The location of the respondent was tested and in order to do so, four new dummy variables were created, named *Hagblevou, Ketapui, Abolave* and *Adidome*. Since five different villages were queried, the fifth village (Dzogblakopé) is the reference point and is not added as dummy to avoid perfect collinearity. Solely two out of four variables are significant and can be said to have an impact. This means that inhabitants of Kétapui and Abolavé have a lower WTP than inhabitants of Dzogblakopé and the two other villages as well. However, since only two variables are significant, it is decided not to take the location parameters further into account. The different devices used in the households were tested as well to have an influence. However, none of the variables *UtilisationsAppareils_T_l_vision,* *UtilisationsAppareils_Radio, UtilisationsAppareils_Lampes* and *UtilisationAppareils_Frigo* has a significant impact. The same is noted when the number of mobile phones is tested. The different charging methods are also considered as a possible influencing factor so five different dummies are added to the original equation. Only the variables of charging at a friend's place or charging at the house of someone in the village are significant and seem to have a big positive relation with the WTP. When the respondent can charge the battery at a friend's place, he or she is willing to pay almost 1,500 CFA more for a powerbank, which sounds somewhat contradictory to what one would expect. However, since only two out of five dummies are significant here, it is decided again to not take them further into account.

6.3.3 Combinations

Different combinations of the significant factors above are tried in order to test the coefficients and their significance. The final equation of the WTP for the powerbank is as follows:

$$WTP = 4{,}217.493 - 14.18349\ \times AgeEquete + 133.2919\ \times PersonnesFamille + 446.3528\ \times Generateur \quad (6)$$

It consists of three different – significant – variables and one constant. This regression has a log likelihood value of -407.99 and a significance level of 0.000, based on all the 347 observations. Table 6 below gives some values of the WTP with the minimum, mean and maximum values of the variables. The WTP for example for the mean values of the first two variables and without a generator equals 4,392.95 CFA. This differs approximately 250 CFA from the WTP of the minimum values and also no generator.

Table 6: WTPs (in CFA) with different values of the variables

	Minimum values		**Mean values**		**Maximum values**	
	No generator	Generator	No generator	Generator	No generator	Generator
WTP	4,138.03	4,584.39	4,392.95	4,839.30	5,977.73	6,124.09

The used values for AgeEnquete are 15, 39.36 and 85. The used values for PersonnesFamille are 1, 5.50 and 20. This table clearly indicates that the difference between the WTPs can be enormous, going from 4,138 CFA to 6,124 CFA. The two WTP values for the mean values of the variables differ not that much from the ones with the minimum values, so these values are more likely to be selected as price for the powerbank. Nevertheless, the age of the potential customer, the number of family members and the possession of a generator influence the potential price of the powerbank.

6.4 Conclusion

A renewable energy installation was installed in Sichem, consisting of six solar panels and four batteries to store the produced energy. This was decided since electricity is the most important energy form used in the centre. To ensure long term usage, three different powerbanks were proposed to the respondents through a questionnaire. Option two showed to be the most wanted powerbank, which can charge mobile phones, provide lighting and power a radio. The WTP for this option amounts to 4,459.98 CFA, but is influenced by the age of the respondent, the amount of family members and the possession of a generator. This option should therefore be used to motivate the centre to maintain the installation, by creating an extra revenue stream. The way in which this option is managed in order to achieve this revenue stream is described in the next chapters.

7 Business model

The fourth and last subquestion is: "Which business model is the best guarantee for a sustainable use of the chosen powerbank?" The answer to this question is a business model that enables Sichem to organise the powerbanks in an economically efficient way. Therefore, different decisions were made based on the gathered information in the three first subquestions. First, the business model canvas of Osterwalder and Pigneur is discussed. Second, different sustainable business model archetypes are discussed that are applicable for this powerbank. Finally, the business model is developed. Since it is not possible for me to test this business model in Sichem within the framework of this master thesis, it might not be a "ready-to-implement" business model, but one that still needs small adaptations.

7.1 The business model and business model canvas

According to Osterwalder and Pigneur (2010), a business model "describes the main thought of how an organisation creates, delivers and keeps value" (Osterwalder & Pigneur, 2010). It is thus a representation of the underlying core logic and strategic choices for creating and capturing value (Gebauer & Saul, 2014). Osterwalder and Pigneur (2010) developed a business model canvas to frame the different elements which are crucial to develop a business model. In total, there are nine different building blocks, namely *customers, value proposition, channels, customer relationships, revenues, key resources, key activities, key partners* and *costs.* These building blocks comprise the four main areas of a company: *customers, supply, infrastructure* and *financial viability*. The canvas is represented in figure 12 below. This canvas helps with the construction of the business model itself since it helps to make sequential decisions. The canvas mainly focusses on big manufacturing companies. In this master thesis, a slightly different situation prevails however. Therefore, the different building blocks were explained, but some are only answered briefly in the design itself.

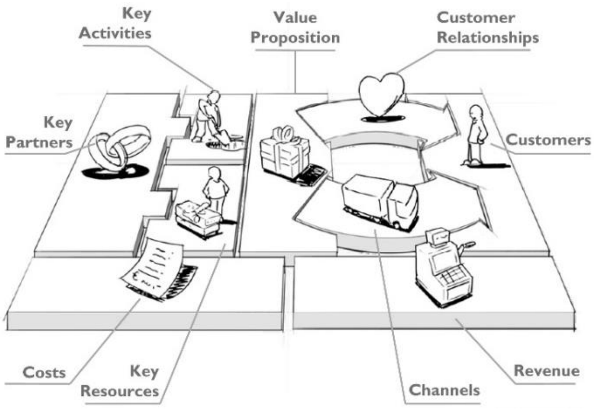

Figure 12: Business model canvas (Osterwalder & Pigneur, 2010)

The first building block is *customers.* In order to determine the customer segment that is targeted, the major consideration is to evaluate which type of customer you will be offering the product or service to, like a specific age category for example. The second building block, *the value proposition*, comprises the exact combination of products and services the company is delivering to their already defined customers. These first two building blocks are also linked to each other through the "value proposition design" of Osterwalder, Pigneur, Bernarda and Smith (2014). This proposition consists of 2 different sides, namely *customer profile* and the *value map* (Osterwalder, Pigneur, Bernarda, &

Smith, 2014). The *customer profile* is used to gain more transparency of your own view on your customers. It takes into account the *customer jobs*, which comprises the different tasks the customer wants to see realised in his life, and the *pains* and the *gains*, which are the negative (resp. positive) results of these customer jobs. At the other side – the *value map* – value is created by listing *products and services*, which match with the customer jobs specified earlier. The *gain creators* and *pain relievers* indicate how the predetermined gains (resp. pains) can be delivered (resp. removed). This shows that a perfect fit between the two sides is needed in order to answer all the demands of the customers and to create as many value as possible (Osterwalder et al., 2014).

The next building block of the canvas, *channels,* represents the way(s) in which the product is brought to the people, where it can be bought and how the communication is managed. The *customer relation* can go from fully automated to personal and the purpose of this building block is to decide which kind of relationship is pursued. A personal relationship enables some help during the buying process, which is not possible with fully automated relationships. The first four building blocks all lead to positive results for the company and therefore result in *revenues*. The next three building blocks all lead to costs instead of revenues. Therefore, the right side of the canvas is sometimes called the "value side" and the left side the "efficiency side". The *key resources* contain all physical, human, intellectual and financial resources of a company. This goes from machines and employees to patents and securities and is therefore very wide. The *key activities* on the other hand are also necessary for a business model to succeed. Key activities do not only contain production itself, but also for example the way problems are solved or how networks are build. The *key partners* contain mostly suppliers. Also, other partners that help the organisation with the business are important partners. Lastly, the *cost structure* is the ninth building block. This comprises the costs created for the activities, partners or resources in order to enhance the efficiency of the company as mentioned above (Osterwalder & Pigneur, 2010).

Knuckles (2016) state that, in order to operationalise a business model, four different dimensions need to be taken into account. The first dimension is the *customer identification*. The second dimension is the *customer engagement* and thus comprises the firm's value proposition. A distinction can be made between the need for a product and the need for the services that this product can fulfil. The third dimension is *value chain linkages*, which looks at the delivered satisfaction. The fourth dimension is *monetization* and is about where, how, when and from whom money is made (Knuckles, 2016). These dimensions cover all the different building blocks of the canvas. The same can be said of Shrimali et al. (2011), who developed different dimensions that signify approximately the same as the blocks of the canvas (Shrimali, Slaski, Thurber, & Zerriffi, 2011).

The business model canvas is too elaborated to use completely for this master thesis and thus not all building blocks are answered profoundly. Nonetheless, this canvas forms a perfect foundation to develop a business model for energy innovations, even in developing countries (Gabriel & Kirkwood, 2016).

7.2 Sustainable business models

Bocken, Short, Rana and Evans (2014) wrote an article concerning sustainable business models. We are globally facing difficulties of rising global population, accelerating global development and environmental impacts. Therefore, Bocken et al. (2014) state that business as usual is not an option anymore for a sustainable future (Bocken, Short, Rana, & Evans, 2014). In order to achieve long-term sustainability, fundamental changes are necessary in the worldwide industry and therefore, eight sustainable business model archetypes are described in the article. A sustainable business model can be defined as "a business model that creates competitive advantage through superior customer value and contributes to a sustainable development of the company and society" (Lüdeke-Freund, 2010). One archetype described by Bocken et al. (2014) was highly applicable for the powerbanks here, namely the archetype "substitute with renewables and natural processes". This archetype is about reducing the environmental impact and tries to increase the resilience of the company by addressing the resource constraints that come along with non-renewable resources for example. An example of an application of this archetype, given by Bocken et al. (2014) is "local renewable energy solutions", which includes for example solar electricity provision in developing markets. This is a perfect match with the powerbanks here: non-renewable electricity is replaced by solar energy, which is a substitution with renewables. A second archetype "deliver functionality rather than ownership" emphasizes that it is important to fulfil needs, but that it does not necessarily needs to be done by owning goods. The developed business model would therefore be more sustainable if a renting system was introduced instead of selling. Then, a household can rent the powerbank when needed but does not have it at home all the time, especially when they do not need it. This reduces the amount of powerbanks needed in total and also increases the prudence of the households with the powerbanks so as not to lose the deposit. Other important aspects that could be included in the business model are: First, including and engaging the stakeholders in the process leads to more long-term well-being, which was done in this case by surveying the villages. Second, prioritizing social and/or environmental benefits instead of economic profit increases the benefits for the local population. Since most costs are carried by NGOs, the needed profit to motivate Sichem to maintain the installation, is less than the profit needed to finance the investment.

8 The business model of the powerbank

In this chapter, a business model for powerbank number two, which charges mobile phones, powers a radio and provides lighting, is developed for the households in villages without electricity. A SWOT-analysis is performed for the business model at the end of this chapter.

8.1 The business model

In this part, the business model canvas is applied on powerbank number two. The different building blocks are specified.

Value proposition. The chosen energy innovation is powerbank number two. This powerbank can deliver three different services, namely charging mobile phones, providing lighting and powering a radio. This powerbank is different from the powerbanks already on the market, since it is from Sichem, more sustainable, delivers three different services and has a good quality, unlike most powerbanks there. Furthermore, most powerbanks have solely a USB-port, which can charge only new smartphones and nothing else. One of the important characteristics of the chosen powerbank was the compatibility with both smart- and dumbphones. As Knuckles (2016) mentioned, a distinction needs to be made between the need for a product and the need for the services that this product can deliver. For our powerbank, this means more specifically that customers do not want powerbanks per se, but they want services that can be fulfilled using these powerbanks, like charging phones and providing lighting. This is an important difference since it also increases the amount of substitutes for our product. All different charging methods for phones form a threat for this product, just as different kinds of lighting and manners to power a radio. Furthermore, Gebauer and Saul (2014) state that there exist mainly two kinds of household devices. The first type are low-value devices that are given away to the poorest people and the second type are of a higher value and so sold to the more financial viable customers (Gebauer & Saul, 2014). The powerbank corresponds to the second type since it might be too expensive for the poorest inhabitants.

The powerbanks are not sold, but rented to the households. A renting system was chosen since it has several advantages compared to selling. First, a renting system was proposed to the households in the survey, so the gathered information is based on the renting proposal. Second, renting increases the caretaking since otherwise a deposit is lost. Third, unused powerbanks are brought back to Sichem in order to reclaim the deposit, which signifies also less powerbanks needed in general, which is more sustainable. Nonetheless, two disadvantages need to be mentioned as well. First, renting demands an extra initial investment of the customer, namely the deposit, which increases the barrier to rent the powerbank. Second, a renting system is less known in Togo, or at least among the people I spoke, and so this might cause some difficulties. A possible solution for this problem is to introduce the same system as the Energy Kiosks of NGO Solar Zonder Grenzen (IPS, 2017). Here, the user rents the system and pays frequently for the energy that is used, but after having paid a specific amount of money in total, the energy system becomes their property. This same strategy could have been used here, so that the users pay the rental fee every time and when having paid this fee many times, they own the powerbank. However, the powerbank has a high initial cost (about 256,250 CFA), so it would take approximately 103 rentals before the investment cost is paid back. Since this is too much, this option cannot be implemented for our powerbank model. The price for which it will be rented, is calculated in the next chapter (9).

Customers. The targeted customers are the households in the five surrounding (and surveyed) villages, which can be seen as a niche market. This product contributes the most to the development of the poorest households (Shrimali et al., 2011), since they have the least opportunities to fulfil these needs in other ways. However, the poorest people most likely do not have the money to buy these powerbanks since they do not possess a "big" amount of money. Thus, a somewhat higher or wealthier segment is targeted, that is still in need of these services but has already a bit more money to make an upfront payment.

Channels. Sales take place at the library of Sichem, located on the same domain as the other activities. In this library, it is already possible to charge the credit of phones, so this extra product does not demand hiring an extra employee since someone is already present during office hours. When the powerbank gains more interest, it is possible to also create a selling point at the library of Djagblé. This library is also exploited by Sichem and is closer to the villages Kétapui, Abolavé and Adidomé. The communication is mainly done face to face and thus all the employees of Sichem can be used as communication channel. Another communication channel used frequently in Togo is WhatsApp, which can be used to promote the powerbanks as well.

Customer relationships. Automated relationships, like sale over the internet, are mostly cheaper, but within this context, it is not possible. Therefore, the relationship between the customers and the vendor (Sichem) is highly personal. That way, it is possible for the vendor to assist the customer with extra explanation of how the powerbank works etcetera.

Key resources. The most important resources that Sichem needs in order to develop a profitable business of these powerbanks are multiple. First, they need the powerbank installation that enables them to charge these powerbanks. Second, human capital is also important, such as the employee in the library and the employee that maintains the installations. Third, the intellectual capital of the engineers needs to be transferred to the relevant person in Sichem so that the powerbanks and the installation can be repaired when needed. Fourth, Sichem also needs financial support to buy the different powerbanks and to pay the employees. This money is mostly provided by the different NGOs with which Sichem has participations.

Key activities. Organising the rental of the powerbanks is the first activity that is really important. Without this rental, no money is made and thus no business can be developed. Charging these powerbanks when empty and repairing them are also important activities to assure the continuity of the business. Another important activity is the maintenance of the installation of the powerbanks, the maintenance of the powerbanks themselves and also the maintenance of the solar installation of Sichem. If the solar installation is not maintained in the right way, it will shut down and not deliver energy anymore. This maintenance is assured by the extra revenues that Sichem receives for the powerbanks, since it enables them to pay someone to take care of it. The amount of money available for maintenance is calculated in the next chapter. The maintenance of the solar installation does not influence the amount of money that is made with the powerbanks, since the powerbanks are charged using the electricity network. However, these powerbanks were introduced in order to create extra profit so that the solar installation would be maintained. Therefore, the maintenance of the solar installation can be seen as a key activity.

Key partners. NGO SEA and the engineering students are necessary to finance the installation, built the installation and educate the employees of Sichem on the technical details of the installation. This educational aspect increases the knowledge of the people and also ensures that the installation is maintained properly. NGO Togo Debout is an important partner as well, since they helped with the transportation of material. Togo Debout also used their connections to make sure that the engineers got the needed support from Sichem during their stay. They also gave me the right support during my stay so I could conduct my questionnaire as planned.

Revenues and costs. Setting up a business brings along different costs and revenues. The most important costs are charging the powerbanks, reparations, maintenance, the installation and powerbanks themselves. The big investment costs, such as the installation, are carried by the different supporting NGOs, which is an extensive advantage for Sichem. The revenues are the rental fees. The deposits paid also create an incoming cash flow, but cannot be seen as revenues since they need to be paid back upon hand in. The calculation of these costs and revenues is done in the next chapter (9).

8.2 SWOT-analysis

A *SWOT-analysis* is an enumeration of all the different strengths, weaknesses, opportunities and threats of this business model. The first two aspects are internal, which means that it comprises everything that happens inside the "company", in this case inside Sichem. The last two aspects are external, which comprises everything that happens outside of Sichem and which cannot be changed by Sichem itself, only adaptation is possible (Robbins & Coulter, 2012). The strengths and opportunities have a positive influence on the introduction of the idea, while the weaknesses and threats from potential dangers. The SWOT-analysis is represented in figure 13 at the end of this chapter.

8.2.1 Strengths

First, the introduction of the powerbanks enables households to charge mobile phones at home without having to walk several kilometres. Second, this powerbank also provides lighting and powers radios in the cabins. Third, the quality of the powerbank is better than the ones used before, since the weather conditions are taken into account for example. Fourth, customers have no need of the electricity net anymore to fulfil their needs. Fifth, when calculating the price for one mobile phone charge with the powerbank, this powerbank is cheaper than going to a neighbour or a kiosk. Sixth, to charge 100 mobile phones only two displacements are needed: to get the powerbank and to recharge it. Without a powerbank, every time a phone needs to be charged, a displacement is needed. The powerbank therefore demands less effort in total. Seventh, the powerbank is more sustainable than the previous alternatives that are used by the households, such as the flashlights or generators. The rental system makes it even more sustainable since less powerbanks need to be provided, more care is taken and no powerbanks are left somewhere when broken. These seven aspects are all strengths of the business model.

8.2.2 Weaknesses

Renting is a strength of the system since it increases the sustainability, but at the same time, this is the first weakness of the model. Rental is less known among the respondents I surveyed, so it might cause households to lose interest. Second, in order to rent the powerbank, households need to go to Sichem itself. This is most likely a greater distance than to the nearest charging point, such as kiosks or neighbours. The two (greater) displacements can therefore cause households to stay loyal to the current charging points. Third, the amount that needs to be paid at once is at least 50 times bigger than a single time at a kiosk for example. Since the Togolese population in general does not have a saving mentality, such a big amount is rather difficult. Fourth, since it is a rental system, this comes along with a deposit that needs to be paid in advance. This raises the already substantial amount of money that needs to be paid the first time. Fifth, charging at the house of a neighbour or at a kiosk might be considered as a desirable amount of social interaction that is missed by the respondents if it does not occur anymore.

8.2.3 Opportunities

A first opportunity for the model might be the growing population in Togo (and in the world in general). Since more people are living in Togo and thus living in villages without access to the electricity network, the target group of the powerbanks increases every year again. Second, in line with the growth in the number of youth, the number of smartphones increases as well. Smartphones are faster discharged than dumbphones and therefore need more charges in general. The combination of these two opportunities shows that the demand for powerbanks is not likely to decrease in the villages, unless a (working) electricity network is provided by the government.

8.2.4 Threats

First, many different competitors are present in the villages. Different kiosks and/or inhabitants with an electricity source are present in the villages that offer the opportunity to charge mobile phones in exchange for money. This is not the exact same product as we are delivering, but it fulfils to a great extent the same needs. The offered powerbank delivers three services with one device, but for every service, different substitutes can be found in the villages. Second, households might start charging the rented powerbanks at kiosks in order not to go to Sichem for the recharging, which causes less revenues for Sichem. Third, if the government invests in a working electricity network in the villages, the interest in the powerbanks will disappear.

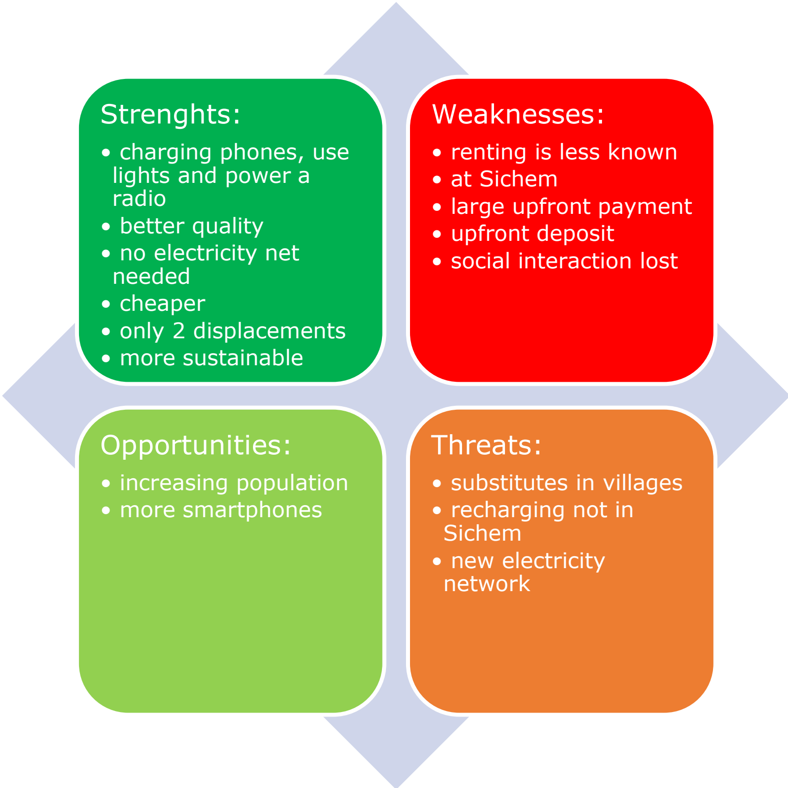

Figure 13: SWOT-analysis of the business model for the powerbanks

9 Cash flow of the business model

In this chapter, the different cash flows for the described business model were calculated and explained and at the end of the chapter a Monte Carlo simulation is presented as well. Two important remarks need to be made before the cash flows are calculated:

First, due to financial and time limitations, instead of powerbanks, in the end it was decided to install two batteries in the villages to charge mobile phones of people presenting themselves at the spot. A business model for this alternative system was developed as well and the cash flows were also calculated in order to enable the engineers to implement the battery system on the local market. I do not report on this alternative business model in the master thesis, but calculations can be found in appendices 4 and 5. For this alternative system, a price per charged mobile phone is demanded to the related person. The installed batteries can charge 40 mobile phones when fully charged. The installation with the solar panels is estimated to last for 15 years before breaking down (when maintained properly). For the business model for the powerbanks on which I report in this master thesis, the costs of the powerbanks were based on the quotations gathered by the engineers before buying the batteries. The other costs used are the actual costs made by them.

Second, the calculations did not take into account the cost of capital and inflation. In Togo, most people do not save money so they also do not invest money in funds. Moreover, the local head of Sichem said that the price of electricity for example remained the same over the past years (A. Dzamah, personal communication, 13 July, 2017), so it can be stated that the rate of inflation could be ignored.

9.1 Cash flows

The chosen powerbank (option 2) was proposed to the respondents as a powerbank with the capacity to charge 100 mobile phones. A quotation for a battery with the capacity of charging 80 mobile phones was available and so was recalculated proportionally from the capacity of 80 to one of 100. Thus, one powerbank can charge 100 mobile phones and can be charged 300 times in total before breaking down on estimate. Normally, such a powerbank can be recharged more often, with a decreasing capacity throughout the lifespan. Nonetheless, it was decided for this master thesis to set the lifespan at 300 recharges because 1) the powerbanks are used under difficult weather conditions (warm and humid), 2) rough treatment is likely and 3) after a certain capacity is lost, the utility becomes negligible and is thus less useful. It is unlikely that more than 5 mobile phones are charged every day with the same powerbank for 15 years, so they do not need replacement during these 15 years.

The costs can be subdivided in fixed and variable costs. The fixed costs are independent of the amount and frequency of rented powerbanks and need to be assigned to a single renting of a powerbank. First, the biggest fixed cost is the energy installation with solar panels. Second, the wage of the responsible person for the maintenance is another fixed cost. Third, the cost of the powerbanks themselves are also fixed: it does not change depending on how many times the powerbanks are rented. Next, there is also a variable cost, namely the cost of charging the powerbanks. Charging one powerbank completely demands on average 3 kWh and the highest possible cost for 1 kWh is 120 CFA, which equals to a variable cost of 360 CFA per recharging of the powerbank. The engineers decided to charge the smaller batteries with the solar panel installation in order to save costs. However, since for this master thesis many different powerbanks are used, this would significantly reduce the amount of produced energy that could be used to charge the emergency batteries. This could mean that Sichem would not be able to bridge a breakdown of the network. Therefore, it was decided to charge the powerbanks with the network. Every time a powerbank is rented, this cost is made since it needs to be fully charged. Summing up the variable and fixed costs leads to the total costs. An important remark can be made concerning some of the fixed costs. Most of the costs are carried by NGO SEA, which means that Sichem only pays for the employee, the charging of the powerbanks and the reparation if necessary. The installation with solar panels was installed any way by the students in order to provide Sichem with energy. Therefore, the installation costs are considered as "not made" for the powerbanks and thus were not allocated to the renting of them. The installation costs can be found in table 7. The costs are expressed both in CFA and euro, using an exchange rate of 655 CFA per euro. The wage of the employee was set on 20,000 CFA per three months. This is a rather low amount, but the engineers estimated the workload of the maintenance to be rather low as well, which means that the employee needs to work approximately a half day per week or maximum 3 days per month. The head of Sichem, estimated the wage for the maintenance to be between 20,000 and 25,000 CFA for 3 months (A. Dzamah, personal communication, 26 March, 2018). According to him, it would be even possible to find someone for 15,000 CFA if that person really needed a job. My supervisor at Sichem stated that a regular wage at Sichem (full-time) is about 40,000 CFA per month (A. E. Y. Attidokpo, personal communication, 29 March, 2018). Therefore, it can be concluded that a wage of 20,000 CFA per three months is a good estimation. One powerbank costs about 256,250 CFA so the total investment cost depends on the amount of powerbanks chosen to be provided.

Table 7: Investment costs

	Costs in CFA	**Costs in euro**
Installation costs made in Belgium	2,146,775.60	3,277.52
Installation costs made in Togo	1,362,900	2080,76
Wage employee per 3 months	20,000	30.534
Cost of 1 powerbank	256,250	391.22

Table 8 contains all the different costs in total and per powerbank rental for different quantities of powerbanks. The price demanded for a single rental is set to be equal to the cost price and so the rental system is calculated to run breakeven (the profit is calculated to be zero). When only one powerbank is provided, the total costs during these 15 years are estimated to be 5,073,926 CFA. A single rental of the powerbanks then costs 16,913 CFA, which is 4 times as much as the willingness to pay of approximately 4,400 CFA. The table further clearly indicates that as the amount of powerbanks increases, so do the total costs, but the cost per rental of a powerbank decreases drastically. This is due to the fixed costs that can be divided over more powerbank rentals and therefore decrease proportionally. The costs per rental reduce to 4,354 CFA for 5 powerbanks, 2,784 CFA for 10 powerbanks, 1,999 CFA for 20 powerbanks and 1,528 CFA for 50 powerbanks. To me, the scenario with 20 powerbanks seems the best for several reasons. First, the price (1,999 CFA) is below the willingness to pay of the average respondent, which means that enough people should be interested in renting the powerbank. Second, the price is substantially lower than the amount of money the respondents now spend on charging 100 mobile phones (between 5,000 and 10,000 CFA). Third, the installation costs are now already 11,994,676 CFA in total for the full 15 years. When more powerbanks were bought, the costs would rise even more. Since this amount is already extensive, it is chosen not to provide more powerbanks. When the system is not popular, more than 20 powerbanks results only in a high investment for nothing. Nonetheless, when less than 20 powerbanks are provided, the number of households that is helped with the innovation is really low. Thus, 20 powerbanks were chosen for now and when possible in the future, more powerbanks are purchased with the revenues gained by Sichem.

The chosen price is also flexible. When taking all the investment costs into account, the breakeven price is 1,999 CFA. However, as already mentioned above, the costs of the energy installation are made any way, even if the energy innovation was not implemented. Only the extra investments made for the powerbanks, such as cables and inverters, were made specifically for the powerbanks. The engineers could only provide the actual costs made rather late and due to time limitation, it was therefore impossible to adapt all the numbers. The calculation in this master thesis are therefore based on the costs at my disposal on the 8th of May, 2018. The extra investment costs for the powerbanks were not mentioned separately and are also not allocated to the powerbank rentals, just as the other installation costs. Nonetheless, they are integrated in the calculations in table 8, under "Installation costs Togo". If these costs would have been allocated to a single powerbank rental, this would increase the price with approximately 105 CFA, as can be seen in table 12 in appendix 6, which is only a small increase. Furthermore, all the investment costs, for both the solar installation and the powerbanks, are carried by NGO SEA and so Sichem does not need to recover this money. Therefore, table 9 shows the differences in costs when these investments are not accounted for. The costs and thus also the breakeven price reduces to 1,414 CFA, which is 585 CFA less. This means that the households can be charged only 1,420 CFA to charge 100 mobile phones. This enables the households to save money that can be used for other things such as food, water and education.

Table 8: Breakeven cash flows for different powerbank quantities (in CFA)

	For 1 powerbank		For 5 powerbanks		For 10 powerbanks		For 20 powerbanks		For 50 powerbanks	
	Total	Per rental	Total	Per rental	Total	Per rental	Total	Per rental	Total	Per rental
Fixed costs	**4,965,926**	**16,553**	**5,990,926**	**3,994**	**7,272,176**	**2,424**	**9,834,676**	**1,639**	**17,522,176**	**1,168**
Installation costs Belgium	2,146,776	7,156	2,146,776	1,431	2,146,776	716	2,146,776	358	2,146,776	143
Installation costs Togo	1,362,900	4,543	1,362,900	909	1,362,900	454	1,362,900	227	1,362,900	91
Powerbanks themselves	256,250	854	1,281,250	854	2,562,500	854	5,125,000	854	12,812,500	854
Wage maintenance	1,200,000	4,000	1,200,000	800	1,200,000	400	1,200,000	200	1,200,000	80
Variable costs	**108,000**	**360**	**540,000**	**360**	**1,080,000**	**360**	**2,160,000**	**360**	**5,400,000**	**360**
Charging powerbanks	108,000	360	540,000	360	1,080,000	360	2,160,000	360	5,400,000	360
TOTAL COSTS	**5,073,926**	**16,913**	**6,530,926**	**4,354**	**8,352,176**	**2,784**	**11,994,676**	**1,999**	**22,922,176**	**1,528**
Total costs in euro	7,746.45	25.82	9,970.88	6.65	12,751.41	4.25	18,312.48	3.05	34,995.69	2.33
REVENUES	**5,073,926**	**16,913**	**6,530,926**	**4,354**	**8,352,176**	**2,784**	**11,994,676**	**1,999**	**22,922,176**	**1,528**
PROFIT	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Table 9: Difference in costs with and without installation costs (for 20 powerbanks)

	Total investment covered		Only powerbanks covered	
	Total	Per rental	Total	Per rental
Fixed costs	**9,834,676**	**1,639**	**6,325,000**	**1,054**
Installation costs Belgium	2,146,776	358	0	0
Installation costs Togo	1,362,900	227	0	0
Powerbanks themselves	5,125,000	854	5,125,000	854
Wage maintenance	1,200,000	200	1,200,000	200
Variable costs	**2,160,000**	**360**	**2,160,000**	**360**
Charging powerbanks	2,160,000	360	2,160,000	360
TOTAL COSTS	**11,994,676**	**1,999**	**8,485,000**	**1,414**
Total costs in euro	18,312.48	3.05	12,954.20	2.16
REVENUES	**11,994,676**	**1,999**	**8,485,000**	**1,414**
PROFIT	**0**	**0**	**0**	**0**

Lastly, the height of the deposit needs to be estimated. Again, the deposit cannot be seen as a revenue since this needs to be paid back upon hand in. The height needs to be high enough to encourage the users to take care of the powerbank and to bring it back when discharged or not used anymore. Also, it needs to suffice to repair the broken powerbanks or to replace when unrepairable. However, when the deposit is too high, this might discourage people to rent a powerbank since the initial price becomes rather high with the deposit included. When the investment costs are not taken into account, it is possible to demand a lower price and a higher deposit. However, when a higher price is charged, some profit can be made which can compensate the potentially broken or not returned powerbanks. Furthermore, it is also possible that changes in costs occur and thus that the final cost price is higher than 1,414 CFA. Therefore, a price of 2,500 CFA is charged. This means that the revenues increase to 15,000,000 CFA and a profit of 6,515,000 CFA is made over 15 years. This is enough to replace approximately 2 powerbanks each year or more specifically that 10% of the powerbanks can be replaced every year, which is a good approximation of what can be expected to be broken or not returned. If less powerbanks are broken, this profit can be used to buy extra powerbanks to expand the system or to renew (parts of) the installation after 15 years, when it is expected to break down. This profit of 1,000 CFA is also a small buffer for when the costs are higher than calculated here. Further, a deposit of 1,500 CFA is charged. This 1,500 CFA deposit is relatively high, so that the renter feels the need to bring it back. The total investment is thus 4,000 CFA. Knowing that a small water bag costs 25 CFA and a meal along the road can already be found for

100 CFA, this could be seen as a relatively high amount, but it is not insurmountable for sure. A SIM card for example costs approximately 1,200 CFA.

As a conclusion, it can be stated that the powerbanks are rented for the price of 2,500 CFA. This is 1000 CFA more than the cost price, which gives Sichem the opportunity to save some money for the future. A deposit of 1,500 CFA is asked, which does not increase the initial investment too much. The first rental therefore demands an investment of 4,000 CFA, which is still 400 CFA lower than the calculated willingness to pay and 1,000 CFA cheaper than the minimum cost for charging 100 mobile phones somewhere else.

9.2 Monte Carlo simulation

A Monte Carlo simulation is a sensitivity analysis that enables to vary some parameters according to defined distributions (Boardman, Greenberg, Vining, & Weimer, 2014). As a result, a histogram is provided with all the different possible results and the chance of getting this result. Based on this histogram, decisions are made with more certainty.

As mentioned above, the wage of the employee responsible for the maintenance can have different values. It might be possible for Sichem to hire someone at the cost of 15,000 CFA per three months, but it might also be 25,000 CFA. The most likely wage is 20,000 CFA, so this value was used in the calculations above. To make sure that fixing the wage at this level is not an over- or underestimation, a Monte Carlo simulation was carried out, which here consists of 10,000 experiments and 1 varying parameter, namely wage. The wage is defined as having a normal distribution with an average of 20,000 and a standard deviation of 1,750. These values were chosen since the graph comprises the most likely values and no indications are present to choose another distribution. The result of this simulation is shown in figure 14 below. On the left axis the chances are listed and on the right axis the frequencies.

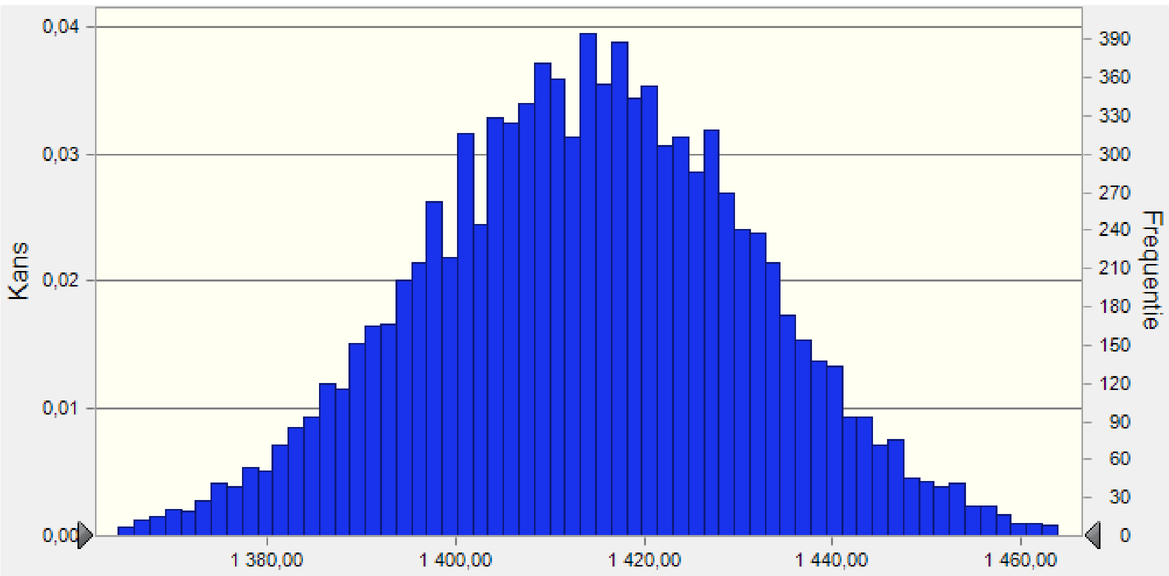

Figure 14: Histogram Monte Carlo simulation powerbanks

This histogram indicates that the costs are lower than 1,500 CFA with a 100% guarantee. This guarantee states as well that the costs are never below 1,300 CFA. Based on the figure, it is likely to state that the cost price and thus also the break-even price lies between 1,400 CFA and 1,430 CFA. The calculated price of 1,414 CFA is therefore a good estimation of the possible price and can be stated as correct. The other parameters were not varied in the Monte Carlo simulation. The costs made by the engineers do not vary, just as the price of a powerbank. The cost price of electricity (in kWh) is fixed at 120 CFA per kWh even though there are three different tranches, as mentioned in chapter 3. Since charging these powerbanks is an extra activity for Sichem and they are already consuming electricity from the highest tranche, the highest price is charged for the powerbanks. The amount of powerbanks is the only parameter that can be varied as well. Nonetheless, the chosen amount was based on the calculation presented in table 8 and not on results from a Monte Carlo simulation. The total investment cost was important, but also the minimum amount needed to deliver surplus value to the inhabitants of the villages. Thus, all the costs, except for the wage, are fixed and are not used as varying parameters in the Monte Carlo simulation.

10 Conclusions

A new – renewable – energy installation was installed at the Sichem centre in Togo. This installation exists of six solar panels and four batteries and enables Sichem to bridge breakdowns of the electricity network. To make sure that this solar installation is used in the long term, an extra add-on was sought to motivate the responsible persons at Sichem to maintain the solar installation and to keep using it. This add-on is an energy innovation, namely a powerbank, which can deliver functionalities to the inhabitants of the surrounding villages. This powerbank provides motivation by inducing a revenue stream which stops when the solar installation breaks down and which enables Sichem to pay for the maintenance. However, just providing the powerbanks does not suffice: they must be managed in the right way to ensure that it is profitable. A business model needed to be developed and so different research questions and subquestions were specified.

The main research question of this master thesis was: "What is the business model for the locally selected powerbank that will provide the local population of the Sichem centre in Dzogblakopé, Lomé, Togo with energy in a sustainable way?" In order to answer this question, four different subquestions were defined. This chapter summarizes the answers to these subquestions and concludes with an answer to the main question.

The first subquestion was: "What are the current costs and applications of energy for both the Sichem centre and the surrounding villages?" Sichem has a connection to the electricity network and thus electricity is the most used energy form for them. Different machines are used so the energy need is quite big. In the villages, the opposite it true: no network is available and thus the inhabitants are forced to use wood, gas or charcoal. Energy is mostly used for cooking, lighting or charging mobile phones.

The second subquestion was: "Which characteristics are the most important for the solar installation and the powerbanks?" The quantitative research showed that both the solar installation and the powerbanks needed to be of good quality, especially the batteries, since they tend to break down often due to the weather conditions. The powerbanks also needed to be good in terms of price, transportability and compatibility. Based on these results, three different powerbanks were queried in the villages. Also, this information was used by the engineers when designing the installation.

Subquestion three was: "What is the *willingness to* pay (WTP) for the powerbanks?" and was answered by doing a qualitative research and organising a survey in five different villages. The WTP of the three powerbanks was estimated using the *double-bounded dichotomous choice* method. The chosen powerbank can charge mobile phones, use lights and power radios with a WTP of 4,459.98 CFA. This can be compared to the price of a single recharge of a mobile phone battery, which costs between 50 and 100 CFA.

The last subquestion was: "Which business model is the best guarantee for a sustainable use of the chosen powerbank?" It was decided to rent powerbanks at the library of Sichem for the price of 2,500 CFA, with a deposit of 1,500 CFA to be paid upfront, which brings the total investment cost to 4,000

CFA. Renting was chosen since it is more sustainable than selling due to the better caretaking and the lower amount of batteries dumped and thus needed in total so as not to lose the deposit. The total initial investment thus amounts to 4,000 CFA, which is still below the estimated WTP of 4,459.98 CFA. This amount can be compared for example to the prices of a small bag of water, which is 25 CFA, a meal along the road, which is 100 CFA and a SIM card, which costs 1,200 CFA. In total 20 powerbanks are provided and one employee is hired to do the maintenance of the installation, which is estimated to take three days per month. The total cost per powerbank rental is estimated at 1,414 CFA, so a profit of 1,000 CFA is made per rental. This profit enables Sichem to save money to repair and/or replace broken powerbanks. During the years, if the system is popular, extra powerbanks can be purchased as well. Per year, I estimate that two new batteries can be bought with the profit made by the renting system.

The answer to the main research question is thus the sustainable business model just described. This renting model for the second powerbank type is based on the needs of the respondents and takes into account the important characteristics mentioned during the research, such as quality. The WTP was also taken into account to make sure that the inhabitants of the villages would be able to rent these powerbanks. The model also considers that Sichem has to manage the renting and thus it cannot be too time-consuming and unpractical. This model thus enables Sichem to manage the add-on in the right way and gain some profit. An employee is financed to maintain the solar installation so that the chances of long term usage increase. With the chances of long term usage also the provision with sustainable energy increases and thus the centre will be able to continue their activities despite potential breakdowns of the network.

11 Limitations

This master thesis has several limitations. First of all, the place of data collection influences the results of this master thesis. Since this happened in Sichem, Togo, the DB-DC method was chosen in order to have an easier manner of posing valuation questions, while still gaining the wanted and needed information. This increased the sample size needed for reliable results considerably.

Second, aspects such as culture and language (French and Ewe) influenced the way the questions were formulated, posed and answered. It also influenced the communication with the supervisors and the students which helped me.

Third, another limitation is connected to the implementation of the business model. The result of this master thesis is a business model for the chosen energy innovation. Since I will not return to Sichem to implement this business model, it is possible that it will not be executed exactly like described. I expect the promotors to follow-up the implementation in future projects with new students, but it will not be me who takes care of this follow-up.

Fourth, a lot of information used in this master thesis was gathered in Sichem and the surrounding villages by myself. Mostly, this information was gathered by querying the inhabitants or demanding Antoine and/or Arsène for information, such as wages and prices of powerbanks. Therefore, quite some information cannot be checked in literature or official sources. However, since I am trying to help Sichem with their development, the local community was really helpful and thus it can be expected that the information is reliable.

Fifth, this research was carried out specifically for the Sichem centre in Togo. This means that the costs, applications, innovations … and especially the business model are developed for the specific demands and wishes of the centre and its surrounding villages. This model cannot simply be used for other villages and other centres. It might be possible to use this information and this business model as a starting point for a similar case, but it has to be adapted to the specific needs of the people in order to make sure that it works. Therefore, it seems best to conduct a local field research to demand the needs of the people and to analyse the context in which the innovation will be introduced. The generalisation of this research can thus not be assured.

Sixth, due to time limitations, it was not possible to use the most up to date numbers for the cash flow calculations. The engineers could only provide these costs rather late and so I was obliged to calculate the cash flows using the costs at my disposal on the 8th of May, 2018.

12 References

Attidokpo, A. E. Y. (2016). *La prise en charge des services publics par les communautés à la base à l'épreuve de la faible mobilisation communautaire au Togo.* (Ph.D.), Université de Lomé.

Banque Centrale des Etats de l'Afrique de l'Ouest. (2018). Histoire du Franc CFA. Consulted on 28 April, 2018. Retrieved from https://www.bceao.int/fr/content/histoire-du-franc-cfaBanque

Boardman, A., Greenberg, D., Vining, A., & Weimer, D. (2014). Cost-Effectiveness Analysis *Cost-Benefit Analysis* (Vol. 4): Pearson New International Edition.

Bocken, N. M. P., Short, S. W., Rana, P., & Evans, S. (2014). A literature and practice review to develop sustainable business model archetypes. *Journal of Cleaner Production, 65*, 15.

Bradford, W. D., Kleit, A. N., Krousel-Wood, M. A., & Re, R. M. (2004). Willingness to pay for telemedicine assessed by the double-bounded dichotomous choice method. *Journal of Telemedicine and Telecare, 10*(6), 325-330.

Broeders , J., & Aerts, J. (2015). *Opbouw van een duurzame installatie voor energieopwekking en -opslag in basisschool 'Futur du Sénagal'*. (Master thesis), Hasselt University, Faculty of Industrial Engineering Sciences.

Cai, Y., Deilami, I., & Train, K. (1998). Customer retention in a competitive power market: Analysis of a 'double-bounded plus follow-ups' questionnaire. *The Energy Journal, 19*(2), 191-215.

Calia, P., & Strazzera, E. (2000). Bias and efficiency of single versus double bound models for contingent valuation studies: a Monte Carlo analysis. *Applied Economics, 32*(10), 1329-1336.

Cameron, T. A., & Quiggin, J. (1994). Estimation using contingent valuation data from a "dichotomous choice with follow-up" questionnaire. *Journal of environmental economics and management, 27*(3), 218-234.

Central Intelligence Agency. (2018, March 14, 2018). The World Factbook - Africa: Togo. Consulted on 10 October, 2017. Retrieved from https://www.cia.gov/library/publications/the-world-factbook/geos/to.html

Compari. (2013). Map of Africa with Togo marked. Consulted on 11 October, 2017. Retrieved from https://nl.ulule.com/compari-togo/

Czajkowski, J. R. (2007). *Essays in environmental economic valuation and decision making in the presence of an environmental disaster.* (3305951 Ph.D.), Florida International University, Ann Arbor. ProQuest Central database.

Droogmans, D., & Puttenaers, K. (2018). *Onderzoek en implementatie van een distributiecentrum voor hernieuwbare energie in Sichem, Togo.* (Master thesis), Hasselt University, Faculty of Industrial Engineering Sciences.

Dobility Inc. (2017). SurveyCTO. Consulted on 23 October, 2017. Retrieved from https://www.surveycto.com/index.html

Donfouet, H. P. P., Jeanty, P. W., & Mahieu, P.-A. (2014). Dealing with internal inconsistency in double-bounded dichotomous choice: an application to community-based health insurance. *Empirical Economics, 46*(1), 317-328.

Facture d'energie basse tension, FE-707230104302, Compagnie energie electrique du Togo (2017).

Finance Network. (2018). West-Afrikaanse Frank. Consulted on 28 April, 2018. Retrieved from https://www.wisselkoers.nl/cfa_frank

Gabriel, C.-A., & Kirkwood, J. (2016). Business models for model businesses: Lessons from renewable energy entrepreneurs in developing countries. *Energy Policy, 95*, 336-349. doi: http://dx.doi.org/10.1016/j.enpol.2016.05.006

Gebauer, H., & Saul, C. J. (2014). Business model innovation in the water sector in developing countries. *Science of the Total Environment, 488-489*, 512-520.

Hair, J. F., Black, W. C., Babin, B., J., & Anderson, R. E. (2014). *Multivariate Data Analysis* (Vol. 7): Pearson Education Limited.

Hanemann, M., Loomis, J., & Kanninen, B. (1991). Statistical efficiency of double-bounded dichotomous choice contingent valuation. *American journal of agricultural economics, 73*(4), 1255-1263.

IPS. (2017). Belgen verkopen zonne-energie in Togo per sms. *Mo**. Consulted on 15 October, 2017. Retrieved from https://www.mo.be/nieuws/belgen-verkopen-zonnestroom-togo-sms

Jacobs, J. (2014). Kristof Dom en Solar Zonder Grenzen tonen Togo de weg naar (betaalbaar) licht. Consulted on 15 October, 2017. Retrieved from http://www.viw.be/nl/2015/5/21/kristof-dom-en-solar-zonder-grenzen-tonen-togo-de-weg-naar-betaalbaar-licht

Jeanty, P. W., Haab, T., & Hitzhusen, F. (2007). *Willingness to pay for biodiesel in diesel engines: a stochastic double bounded contingent valuation survey.* Paper presented at the American Agricultural Economics Association Annual Meeting. Portland, Oregon, USA.

Knuckles, J. (2016). Business models for mini-grid electricity in base of the pyramid markets. *Energy for Sustainable Development, 31*(Supplement C), 67-82. doi: https://doi.org/10.1016/j.esd.2015.12.002

Lopez-Feldman, A. (2010). Doubleb: Stata module to estimate contingent valuation using Double-Bounded Dichotomous Choice Model. Consulted on 6 February, 2018. Retrieved from http://ideas.repec.org/c/boc/bocode/s457168.html

Lopez-Feldman, A. (2012). Introduction to contingent valuation using Stata. *MPRA Paper No. 41018*. Retrieved from http://mpra.ub.uni-muenchen.de/41018/

López-Feldman, A. (Producer). (2013). Introduction to Contingent Valuation Using Stata.

Lüdeke-Freund, F. (2010). Towards a conceptual framework of business models for sustainability. *ERSCP-EMU Conference*, 1-28.

McLeod, D. M., & Bergland, O. (1999). Willingness-to-Pay Estimates Using the Double-Bounded Dichotomous-Choice Contingent Valuation Format: A Test for Validity and Precision in a Bayesian Framework. *Land Economics, 75*(1), 115-125.

Osterwalder, A., & Pigneur, Y. (2010). *Business Model Generatie: een handboek voor visionairs, game changers en uitdagers* (H. v. d. Ham, Trans. T. Clark Ed.). Deventer: Kluwer, Patrick van der Pijl.

Osterwalder, A., Pigneur, Y., Bernarda, G., & Smith, A. (2014). *Value Proposition Design* (T. Weijers, Trans. Vol. 2). Deventer: vakmedianet.

Robbins, S. P., & Coulter, M. (2012). Strategisch Management (K. de Vries & H. van der Kolk, Trans.) *Management* (11 ed.). Amsterdam: Pearson Benelux.

Sekaran, U., & Bougie, R. (2013). *Research Methods for Business: a Skill-Building Approach* (6th ed.). United Kingdom, West Sussex: John Wiley & Sons Ltd.

Shrimali, G., Slaski, X., Thurber, M. C., & Zerriffi, H. (2011). Improved stoves in India: A study of sustainable business models. *Energy Policy, 39*(12), 7543-7556. doi: https://doi.org/10.1016/j.enpol.2011.07.031

Solar Zonder Grenzen. (2018). Solar Zonder Grenzen - Over ons. Consulted on 5 February, 2018. Retrieved from http://solarzondergrenzen.be/ons/

Togo Debout VZW. (2018, 2018). Samen werken aan ontwikelling. Consulted on 6 February, 2018. Retrieved from http://www.togodebout.be/

United Nations Development Program. (2016a). Human Development Data (1990-2015). Consulted on 20 October, 2017. Retrieved from http://hdr.undp.org/en/data

United Nations Development Program. (2016b). Human Development Index (HDI). Consulted on 20 October, 2017. Retrieved from http://hdr.undp.org/en/content/human-development-index-hdi

United Nations Development Program. (2016c). Table 1: Human Development Index and its components. Consulted on 20 October, 2017. Retrieved from http://hdr.undp.org/en/composite/HDI

Venkatachalam, L. (2004). The contingent valuation method: a review. *Environmental Impact Assessment Review, 24*(1), 89-124. doi: http://dx.doi.org/10.1016/S0195-9255(03)00138-0

Veronesi, M., Alberini, A., & Cooper, J. C. (2011). Implications of Bid Design and Willingness-To-Pay Distribution for Starting Point Bias in Double-Bounded Dichotomous Choice Contingent Valuation Surveys. *Environmental and Resource Economics, 49*(2), 199-215.

VZW BISZ. (2017). vzw BISZ - over ons. Consulted on 7 March, 2018. Retrieved from https://vzwbisz.be/about/

vzw Students for Energy in Africa. (2017). Students for Energy in Africa. Consulted on 20 October, 2017. Retrieved from https://studentsforenergyinafrica.com/

Yoo, S.-H., & Kwak, S.-Y. (2009). Willingness to pay for green electricity in Korea: A contingent valuation study. *Energy Policy, 37*(12), 5408-5416. doi: http://dx.doi.org/10.1016/j.enpol.2009.07.062

Zografakis, N., Sifaki, E., Pagalou, M., Nikitaki, G., Psarakis, V., & Tsagarakis, K. P. (2010). Assessment of public acceptance and willingness to pay for renewable energy sources in Crete. *Renewable and Sustainable Energy Reviews, 14*(3), 1088-1095. doi: http://dx.doi.org/10.1016/j.rser.2009.11.009

13 Appendices

13.1 Appendix 1: Questionnaire

Field	Question	Answer (options)
Introduction	Ce questionnaire est mis en place dans le cadre d'une thèse de maîtrise en collaboration avec le centre Sichem (aussi connu comme ferme de Sichem). Le sujet de ce questionnaire est l'usage, la valeur et l'importance d'innovations en énergie et le potentiel d'une nouvelle installation d'énergie renouvelable. L'objectif est d'explorer et de rechercher la valeur que les ménages associent à l'énergie. De plus, j'aimerais vous assurer qu'il n'y a pas de bonnes ou mauvaises réponses et que toutes les réponses seront traitées de façon anonyme et confidentielle. Le questionnaire dure environ 20 minutes. Merci en avance de remplir ce questionnaire et d'ainsi m'aider à réaliser ma thèse de maîtrise.	
location *(required)*	Où est-ce que vous trouvez? GPS coordinates can only be collected when outside.	
CompositionFamille	Les questions suivantes concernent la composition de la famille.	
PersonnesFamille *(required)*	De combien de personnes la famille se compose-t-elle ? (La famille ici veut dire : toutes les personnes qui habitent chez vous la plupart du temps. Préférablement, ces personnes sont aussi famille de vous.)	
IdentiteEnquete	Les questions suivantes concernent l'identification de l'enquêté.	
NomPrenomEnquete *(required)*	Nom et prénom (noter le nom en MAJUSCULES et le prénom normal)	
LeSexeEnquete *(required)*	Quel est le sexe de cette personne?	Masculin (M) Féminin (F)
AgeEnquete *(required)*	Quel est l'âge de cette personne ?	
PaimentNourritureEnquete *(required)*	Est-ce que cette personne participe au paiement de la nourriture ?	Oui Non
TelephonePortableEnquete *(required)*	Est-ce que cette personne dispose d'un téléphone portable ?	Oui Non
IdentiteCM	Les questions suivantes concernent l'identification du chef de ménage.	
NomPrenomCM	Nom et prénom (noter le nom en MAJUSCULES et le prénom normal)	
LeSexeCM	Quel est le sexe de cette personne?	Masculin (M)

		Féminin (F)
AgeCM	Quel est l'âge de cette personne ?	
LienDeParenteCM	Quel est le lien de parenté vous liant à cette personne ?	Epoux/épouse Conjoint(e) Mère/père Fils/fille Petit-fils/petite-fille Frère/sœur Grand-mère/grand-père Autre
PaimentNourritureCM	Est-ce que cette personne participe au paiement de la nourriture ?	Oui Non
TelephonePortableCM	Est-ce que cette personne dispose d'un téléphone portable ?	Oui Non
FormationCM	Quelle est la formation du chef de ménage? niveau de l'éducation	
RevenuFamille	Les questions suivantes concernent le revenu de la famille.	
TypeDeTravail *(required)*	Quel type de travail a le chef de ménage ?	Régulier(ière) Indépendant(e) Occasionnel(le)
TravailExactCM *(required)*	Que fait le chef de ménage exactement comme travail ?	
TravailAutres	Type de travail d'autres personnes qui participent au paiement de la nourriture.	
TypeDeTravailAutre1	S'il y a une autre personne qui contribue au paiement de la nourriture, quel type de travail a-t-elle ? pas oblige	Régulier(ière) Indépendant(e) Occasionnel(le)
TravailExactAutre1	Que fait cette personne exactement ? pas oblige	
UtilisationAppareils-Electroniques	Les questions suivantes concernent l'utilisation d'autres appareils électriques et électroniques actuellement.	
UtilisationAppareils *(required)*	Quels appareils électroniques utilisez-vous ? (des portables exclus)	Télévision Radio Lampes Frigo Autre
AutresAppareils *(required)*	Quels autres appareils vous utilisez? Question relevant when: selected (UtilisationAppareils, 'Autre')	
AccesReseauElectrique *(required)*	Avez-vous accès au réseau électrique à la maison ? (seulement demander cette question aux ménages à Sichem I et II)	Oui Non

Generateur *(required)*	Avez-vous un générateur?	Oui Non
GenerateurCouteLuiMeme *(required)*	Combien ce générateur coûte-t-il par semaine ? Question relevant when: selected (Generateur, 'Oui')	
GenerateurCoute-Consommation *(required)*	Combien coûte la consommation en carburant par semaine ? Question relevant when: selected (Generateur, 'Oui')	
RechargementBatterie-TelephonesPortables	Les questions suivantes concernent le (re)chargement de la batterie des téléphones portables.	
CombienPortables *(required)*	Combien de téléphones portables sont à la disposition de votre ménage ? (Cette question a le but d'être sûr qu'on utilise des téléphones portables dans la famille. Les questions suivantes ne sont posées que si au moins un téléphone est à la disposition du ménage.)	
MoyenRechargement *(required)*	Quels moyens utilisez-vous pour recharger la batterie des téléphones portables ? plusieurs options possibles Question relevant when: CombienPortables > 0	A la maison avec le réseau électrique Chez des voisins/ amis à la maison Dans le village, chez quelqu'un avec une source d'électricité (payant) Dans un kiosque Au travail Autre
AutreMoyenCharger *(required)*	Quel autre moyen utilisez-vous ? Question relevant when: selected (MoyenRechargement, 'Autre')	
CombienFoisChargerAu-Kiosque *(required)*	Si vous rechargez votre téléphone portable dans un kiosque, combien de fois par moi le faites-vous ? Question relevant when: selected (MoyenRechargement, 'Kiosque')	1-2 fois 3-4 fois 5-6 fois 7-8 fois 9-10 fois Plus de 10 fois
PrixRechargementKiosque *(required)*	Que payez-vous par rechargement de la batterie dans un kiosque ? (le prix de 1 rechargement) Question relevant when: selected (MoyenRechargement, 'Kiosque')	
CombienFoisChargerAu-Village *(required)*	Si vous rechargez votre téléphone portable dans le village chez quelqu'un avec une source d'électricité, combien de fois par mois le faites-vous ?	1-2 fois 3-4 fois 5-6 fois

	Question relevant when: selected (MoyenRechargement, 'QuelquunDeVillage')	7-8 fois 9-10 fois Plus de 10 fois
PrixRechargementAuVillage *(required)*	Que payez-vous par rechargement de la batterie chez quelqu'un avec une source d'électricité ? (le prix de 1 rechargement) Question relevant when: selected (MoyenRechargement, 'QuelquunDeVillage')	
CombienFoisBatteriePlate *(required)*	Combien de fois par mois vous ne disposez pas d'un téléphone portable parce que la batterie est déchargée ? Question relevant when: CombienPortables > 0	Jamais 1-2 fois 3-4 fois 5-6 fois 7-8 fois 9-10 fois Plus de 10 fois
OptionsBatteries	Les questions suivantes concernent une option de nouveau service.	
ExplicationOption1	Il est possible que la ferme Sichem conçoive un nouveau système pour recharger les téléphones. C'est un système que vous pourriez utiliser à la maison. Il s'agit d'une batterie dans une boîte, connectée avec des chargeurs conçus pour différents types de téléphones. La batterie est chargée à Sichem avec des panneaux solaires. (Montrez une esquisse du système). Sichem vous propose d'échanger la batterie quand elle est déchargée, de sorte que vous ayez toujours une batterie pleine chez vous, à votre disposition. Une batterie remplie suffit pour recharger entièrement une centaine de téléphones. Cette batterie peut également servir à charger une lampe portable pour dans la maison. La charge de la batterie devrait alors être suffisante pour 50 chargements de téléphone et pour la lampe pendant deux semaines. Tous les téléphones portables modernes sont compatibles avec le système, donc seulement pour des vieux téléphones, on n'est pas sûr de la compatibilité.	
AvantagesDesavantages1	Avantages et désavantages possibles	
AvantagePlusInteressant1 *(required)*	Qu'est-ce que vous pensez des avantages potentiels de ce système ? Indiquez un avantage dont vous trouvez que c'est le plus important.	La batterie est toujours disponible à la maison. Tout le monde à la maison peut l'utiliser. Le système peut aider à ne jamais se retrouver avec un

		téléphone plat et à toujours avoir de la lumière dans la maison. Le système peut aider à traverser les coupures d'électricité. Je pourrais charger aussi les téléphones des visiteurs et demander une contribution.
AvantageMoinsInteressant1 *(required)*	Qu'est-ce que vous pensez des avantages potentiels de ce système ? Indiquez seulement un avantage que vous trouvez le moins intéressant.	La batterie est toujours disponible à la maison. Tout le monde à la maison peut l'utiliser. Le système peut aider à ne jamais se retrouver avec un téléphone plat et à toujours avoir de la lumière dans la maison. Le système peut aider à traverser les coupures d'électricité. Je pourrais charger aussi les téléphones des visiteurs et demander une contribution.
DesavantagePlusImportant1 *(required)*	Qu'est-ce que vous pensez des désavantages potentiels de ce système ? Indiquez le désavantage dont vous trouvez que c'est le plus important.	La batterie (externe) risque de casser rapidement. Il y a beaucoup de membres dans notre famille qui l'utiliseront et la batterie sera vite plate. On doit faire plus d'effort (louer une batterie) pour arriver au même résultat (recharger les batteries). Beaucoup de visiteurs, amis et voisins viendront également charger leur téléphone ici (sans payer). Il y a un grand risque de vol. Pour moi et ma famille, c'est très difficile pour payer un grand montant.

DesavantageMoinsImportant1 *(required)*	Qu'est-ce que vous pensez des désavantages potentiels de ce système ? Indiquez seulement un désavantage que vous trouvez le moins important.	La batterie (externe) risque de casser rapidement. Il y a beaucoup de membres dans notre famille qui l'utiliseront et la batterie sera vite plate. On doit faire plus d'effort (louer une batterie) pour arriver au même résultat (recharger les batteries). Beaucoup de visiteurs, amis et voisins viendront également charger leur téléphone ici (sans payer). Il y a un grand risque de vol. Pour moi et ma famille, c'est très difficile pour payer un grand montant.
ExplicationEstimationPrix1	Les questions suivantes concernent le prix que vous trouvez juste pour un tel système. Il s'agit ici du prix d'un (1) chargement de la grande batterie, qui convient pour charger la batterie d'un téléphone portable une centaine de fois.	
Prix1 *(required)*	Seriez-vous prêt à donner 3500F ?	Oui Non
Prix1PlusY *(required)*	Seriez-vous prêt à donner 5000F? (5000F est le même prix pour charger 100 fois des portables ailleurs) Question relevant when: selected (Prix1, 'Oui')	Oui Non
Prix1MoinsY *(required)*	Seriez-vous prêt à donner 2000F ? Question relevant when: selected (Prix1, 'Non')	Oui Non
Option2	Imaginons maintenant que la batterie ne peut pas seulement charger des portables et des lampes, mais elle alimente aussi un radio. Cette batterie est aussi chargée à Sichem avec des panneaux solaires. Sichem vous propose d'échanger la batterie quand elle est déchargée, de sorte que vous ayez toujours une batterie pleine chez vous, à votre disposition. Qu'est que vous pensez serait juste comme prix pour un tel système ? Il s'agit ici du prix d'un (1) chargement, qui convient pour charger les portables une centaine de fois.	
Prix2 *(required)*	Seriez-vous prêt à donner 3500F ?	Oui Non

Prix2PlusY *(required)*	Seriez-vous prêt à donner 5000F? Question relevant when: selected (Prix2, 'Oui')	Oui Non
Prix2MoinsY *(required)*	Seriez-vous prêt à donner 2000F ? Question relevant when: selected (Prix2, 'Non')	Oui Non
Option3	Imaginons maintenant qu'une autre sorte de batterie est mis en place. Cette batterie ne peut plus charger des portables et des lampes, mais elle est capable d'alimenter une télévision pendant un mois (à cause d'une capacité limitée de la batterie). Cette batterie est aussi charger à Sichem avec des panneaux solaires. Sichem vous propose d'échanger la batterie quand elle est déchargée, de sorte que vous ayez toujours une batterie pleine chez vous, à votre disposition. Qu'est que vous pensez serait juste comme prix pour un tel système ? Il s'agit ici du prix d'un (1) chargement, qui convient pour charger les portables une centaine de fois.	
Prix3 *(required)*	Seriez-vous prêt à donner 3500F ?	Oui Non
Prix3PlusY *(required)*	Seriez-vous prêt à donner 5000F? Question relevant when: selected (Prix3, 'Oui')	Oui Non
Prix3MoinsY *(required)*	Seriez-vous prêt à donner 2000F ? Question relevant when: selected (Prix3, 'Non')	Oui Non
OptionPrefere *(required)*	Laquelle des trois options préférez-vous : la batterie pour charger des portables et des lampes, la batterie pour charger des portables, des lampes et un radio ou la batterie pour charger une télévision ?	Option 1 (portables + lampes) Option 2 (portables + lampes + radio) Option 3 (télévision)
MERCI	Un tout grand merci pour le temps que vous avez consacré à répondre à ces questions.	
Remarques	Des remarques, observations, ... d'enquêteur: Cette question est seulement pour les enquêteurs. Ne lisez pas cette question et seulement notez des choses importantes regarder cette questionnaire.	

13.2 Appendix 2: Manuel “How to act as an interviewer”

ENQUETE SUR :

« L’usage, la valeur et l’importance d’innovations en énergie et le potentiel d’une nouvelle installation d’énergie renouvelable »

MANUEL D’ENQUETE

Sichem, Zio, Togo,

10 juillet – 20 aout 2017

Agents Enquêteurs,

Ce manuel a été fait dans le but de vous guider tout au long de l'enquête c'est-à-dire, non seulement dans la phase de formation et de préparation mais aussi durant le processus d'administration des questionnaires auprès des ménages. Chaque point a été minutieusement réfléchi. Considérez donc ce manuel comme un guide de référence apte à vous aider à conduire au mieux votre travail en tant qu'agent enquêteur. Ne soyez jamais trop sûr de vous dans la manière de compléter les questionnaires et n'hésitez jamais à consulter le manuel si vous avez un doute. Je reste aussi disponible pour toutes questions, aucune question ne sera considérée comme stupide.

La priorité doit être donnée à la qualité des données récoltées.

Chapitre 1 : INTRODUCTION AU SUJET ETUDIE

En Afrique, et donc aussi au Togo, il n'y a pas toujours de réseau électrique. Et même s'il y a un réseau électrique, le réseau n'est pas fiable. Ça cause des problèmes différents. Entre autres pour les entreprises, les écoles, les fermes de productions, les kiosques et cetera, qui ne peuvent pas compter sur le net, mais aussi pour les familles et les ménages qui ne peuvent pas utiliser le réseau pour charger leurs portables et leurs lampes. On est donc obligé de produire son énergie lui-même. Parce que les alternatives sont très chères, le centre Sichem (Lomé, Togo) a demandé à ONG « Togo Debout » de chercher une solution renouvelable. Togo Debout et ONG « Students for Energy in Africa » ont commencé à collaborer pour construire une installation d'énergie renouvelable au centre. C'est pour cette raison que je suis ici à Sichem. Beaucoup de projets focalisent à construire des installations d'énergie ou énergétique, mais plus souvent les aspects sociaux et économiques sont oubliés ou négligés. Alors, le but de mon investigation c'est : découvrir les éléments qui sont importants, qui influencent la valeur de l'énergie et aussi découvrir quelles sont les besoins de (les applications d') énergie. L'année prochaine, deux autres étudiants vont aller à Sichem pour construire une installation d'énergie renouvelable. Avec cette installation, ça serait aussi possible de charger des batteries externes (portables) qui peuvent être louées. Les batteries peuvent être utilisées par les ménages et familles à Sichem et les villages autours, mais aussi par des propriétaires de kiosques et elles donnent la possibilité de charger des portables et des lampes sans avoir besoin du réseau électrique.

Le questionnaire se compose de deux parties. La première partie s'adresse à l'usage de et l'accès à l'énergie, la composition de la famille et l'usage des téléphones portables. Plus précisément, on demande par exemple d'indiquer quels appareilles électriques et électroniques on utilise et combien de fois. La deuxième partie concerne trois différentes options de batteries. Les enquêtés sont demandés d'évaluer les avantages, les désavantages et le prix.

Chapitre 2 : CONCEPTS CLES

Le Ménage

Il est l'ensemble composé d'une ou des personnes, apparentées ou non, vivant dans votre logement de la même concession, prenant le plus souvent leurs repas en commun et mettant en commun tout ou une partie de leurs ressources pour subvenir aux besoins courants ou vitaux. Ces personnes reconnaissent l'autorité d'une seule personne qui est le chef de ménage (CM). Une personne est résidente dans le ménage si elle y vit habituellement depuis 6 mois au moins ou depuis moins de temps, mais avec l'intention d'y rester au moins 6 mois (déménagement, mariage, etc.). Donc, le ménage ici est une famille composée de tous les personnes qui habitent dans la maison.

Chapitre 3 : LE DEROULEMENT DE L'INTERVIEW[1]

A. Comment établir des bons rapports avec l'enquêté

- ✓ **Faites dès le début une bonne impression**

Quand vous abordez l'enquêté(e) pour la première fois, faites de votre mieux pour le (la) mettre à l'aise. Mettez l'enquêté dans un état d'esprit favorable pour l'enquête. Abordez-le avec un sourire et présentez-vous.

Après les salutations d'usage, par exemple '*Bonjour Monsieur'*, ou *'Bonjour Madame'*, vous pouvez vous présenter de la manière suivante :
« Je m'appelle___________________. Je suis enquêteur dans le cadre de l'enquête sur l'usage, la valeur et l'importance d'innovations d'énergie au Togo. C'est une étude sur des options de nouveau service d'énergie en collaborations avec le centre Sichem. Je voudrais vous annoncer que vous et votre ménage ont été choisis pour faire partie de notre étude. Je voudrais vous poser quelques questions. »

- ✓ **Ayez toujours une approche positive**

Soyez toujours poli et étendu. N'adoptez jamais un air d'excuses, et n'utilisez pas des expressions telles que *« Etes-vous trop occupé ? »* ou *« Pourriez-vous m'accorder quelques minutes ? »* ou *«Cela vous dérangerait – il de répondre à quelques questions ? »*. De telles questions risquent d'entraîner un refus avant même de commencer. Dites plutôt à l'enquêté *«Je voudrais vous poser quelques questions »* ou *«Je voudrais vous parler quelques instants»*

- ✓ **Mettez l'accent sur le caractère confidentiel des réponses, si nécessaire**

Si l'enquêté hésite à répondre à certaines questions, dites-lui que les informations que vous recueillez restent confidentielles et servent à des fins statistiques ; qu'il ne sera jamais fait mention des noms des personnes dans aucun rapport. Assurez-lui que la loi vous interdit de communiquer ces informations à quelqu'un d'autre, en dehors de vos chefs hiérarchiques dans ce travail.

- ✓ **Répondez franchement aux questions de l'enquêté**

Si l'enquêté vous pose des questions sur l'enquête ou sur la durée de l'interview, donnez-lui des réponses claires sans manifester le moindre énervement. Ayez toujours sur vous vos cartes d'identité. N'hésitez pas à le présenter sur simple demande de vos interlocuteurs.

- ✓ **Faites toujours preuve de sérieux pour votre travail en respectant (si applicable) strictement les dates et heures des rendez-vous convenus avec les membres du ménage.**

[1] Ref.: Manuel de l'agent enquêteur de ECAM, INS, 2007.

B. Conseils pour bien conduire l'interview

✓ **Soyez neutre pendant toute l'interview**

Restez absolument neutre pendant toute l'interview. Ne donnez pas à l'enquêté le sentiment d'avoir donné une réponse juste ou fausse, soit par l'expression de votre visage ou le ton de votre voix. Ne donnez jamais l'impression d'approuver ou de désapprouver les réponses données par l'enquêté.

SURTOUT NE JUGEZ PAS !!!

✓ **Ne suggérez jamais les réponses à l'enquêté.**

✓ **Ne changez pas le sens ou la séquence des questions**

Si l'enquêté a mal compris une question, vous devez répéter la question lentement et clairement. Si l'enquêté ne comprend toujours pas, reformulez la question en prenant soin de ne pas modifier le sens de la question d'origine.

✓ **Traitez les enquêtés qui hésitent avec tact**

Si un enquêté manifeste un certain désintérêt pour l'enquête et refuse de répondre aux questions posées ou de continuer l'interview, vous devez raviver son intérêt. Passez quelques instants à parler des choses sans rapport avec l'enquête (par exemple : sa ville, son village, le temps etc.)

✓ **N'ayez pas d'idées préconçues**

Les stéréotypes sont des généralités qui ne s'appliquent pas à tout le monde, ils sont très dangereux! N'anticipez donc pas la réponse de l'interviewé sur base de ce que vous pensez connaitre, peut-être sera-t-il dans une situation tout à fait différente.

✓ **Ne précipitez pas l'interview**

Posez les questions lentement pour que l'enquêté comprenne bien ce qu'on lui demande. Après avoir posé une question, attendez et donnez-lui le temps de réfléchir. Si l'enquêté se sent bousculé, il donnera des réponses inexactes ou dira tout simplement «je ne sais pas ». Par contre, si c'est l'enquêté qui semble être pressé, dites-lui gentiment que vous n'êtes pas pressé, et invitez-le à travailler posément avec vous.

✓ **Langue de l'interview**

Le questionnaire est rédigé en français. Utilisez la langue officielle. Si dans un ménage donné, on ne parle pas français l'un des membres de l'équipe s'efforcera de traduire les questions à l'enquêté sans en changer le sens.

Remarques : Cinq principes.

Pour accroître les chances de succès dans votre travail assurez-vous du respect de ces cinq principes :

a) Ne jamais commencer les entretiens dans une zone d'enquête sans avoir rencontré les autorités administratives et traditionnelles concernées.
b) Commencer les entretiens dans chaque zone d'enquête par les ménages les plus disponibles, pouvant éventuellement vous faciliter la tâche auprès des autres ménages.
c) Une mauvaise connaissance de votre sujet crée un doute chez les enquêtés et peut faire naître des réticences même chez ceux qui étaient disposés à coopérer. **Assurez-vous que vous maîtrisez votre sujet.**
d) Vous devez en permanence avoir une attitude de courtoisie et savoir vous intégrer dans votre milieu de travail. **Ne faites surtout pas de promesse.**
e) **Respectez toujours l'interviewé,** ne le jugez pas et adopter une attention calme, posée et conciliante.

Chapitre 4 : REMPLIR UN QUESTIONNAIRE

Les questionnaires sont des listes de questions qui doivent être rempli par des différentes personnes dans le centre Sichem et les villages autours. Chaque section contient une série de questions qui doivent être posées dans l'ordre et de manière systématique. L'enquêteur doit éviter cependant de poser explicitement des questions, dont les réponses découlent soit des questions précédentes (« quel est le sexe de votre épouse ? »), soit de ce qu'il peut observer et noter (« Quel est le matériel principal de votre sol ? »).

Les questions à poser à l'enquêté sont montrées sur l'écran du tablet, les éléments en *italique* s'adressent uniquement à vous, afin de vous aider à compléter la réponse et de vous rappeler à la forme du répons (par exemple : *plusieurs options possible)*. Surtout, ne les lisez pas. Les éléments en italique sont :

- *Le type d'informations que doivent contenir les cases de réponse* : nombre de personnes, nombre de fois, nombre d'unités, année, etc.
- Des *informations* afin de vous guidez dans les réponses.

Attention : Tous les questionnaires doivent être remplis par vous-même sur un Tablet.

Si nécessaire, faites de manière précise et concise des observations écrites et pertinentes dans le cadre prévu à la fin du questionnaire. Un espace vous est réservé à la fin afin de communiquer vos impressions par rapport à l'enquête.

Toujours mettez-vous sûr que l'enquêté est une personne qui sait beaucoup de la ménage. Cette personne n'est pas nécessairement le chef du ménage, mais il/elle doit savoir qui habite à la maison, combien de portables il y a dans la ménage, le coût d'énergie et du (re)chargement des portables…

Ne t'adresse jamais à des enfants qui ne savent pas ce qui se passe dans le ménage et demande toujours en avance si cette personne est capable de répondre aux questions.

Chapitre 5 : L'ECHANTILLONNAGE

L'échantillonnage est le processus de sélection des personnes qui seront enquêtés. Ces personnes seront sélectionnées aléatoirement dans des villages déterminés. Autant personnes que possible seront sélectionnées et devront être enquêtées. Dans chaque village, on va diviser et tous les étudiants vont aller dans une direction différente. Ne pose pas les questions dans la rue, mais toujours vient dans la maison des familles (ou devant). Ça veut dire aussi que tu ne poses pas les questions aux personnes qui passent, mais tu choisis toujours une maison dans la rue. Ne pose jamais les questions quand il y a des autres personnes (pas de ce ménage) à côté. Ça va influencer les réponses. Pour être sûr que la sélection de ménage est aléatoirement, c'est important d'aussi omettre des ménages dans la rue. Par exemple, si la rue compte 100 maison, tu omettes quatre (4) maison et continues avec la cinquième (5) maison. Ne choisis pas des maisons côté à côté. Si la famille choisie n'est pas à la maison, tu peux poser les questions à la famille à côté. L'objectif est de faire au moins 15 enquêtes par étudiant par jour et si possible même 20. Le questionnaire n'est pas très longue donc le minimum de 15 est réalisable.

13.3 Appendix 3: Correlation table

Table 10: Correlation table

Significances: *** 0.01; ** 0.05; * 0.10; ° 0.15

	Personne-Famille	AgeEnquete	AgeCM	Televion	Radio	Lampes	Frigo	Combien Portables	Charger à la maison	Charger chez des amis
Personne-Famille	1									
AgeEnquete	-0.0881 °	1								
AgeCM	0.0656	0.6080 ***	1							
Televion	0.0694	-0.0995 *	-0.1033	1						
Radio	0.0328	-0.0344	-0.0593	0.0705	1					
Lampes	-0.1239 **	0.0950*	0.1025	-0.3870 ***	-0.1551 ***	1				
Frigo	-0.0098	-0.0341	0.0367	0.2319 ***	-0.0444	-0.0417	1			
Combien Portables	0.2847 ***	0.0630	0.1086	0.2286 ***	0.1408 ***	-0.0599	0.0968 *	1		
Charger à la maison	0.0744	-0.0594	-0.1032	0.1838 ***	-0.0202	-0.1879 ***	0.0587	0.1952 ***	1	
Charger chez des amis	-0.0654	-0.1041 *	-0.0127	-0.0753	-0.0146	0.0956 *	0.0889 °	-0.0437	-0.0831 °	1
Charger au village	0.1566 ***	0.0684	0.0806	0.0333	-0.1224 **	-0.1796 ***	-0.0656	-0.0349	-0.2852 ***	-0.3301 ***
Charger au kiosque	-0.1313 **	0.0795 °	0.0205	-0.1269 **	0.1568 ***	0.2554 ***	-0.0134	-0.0262	-0.2100 ***	-0.2431 ***
Charger au travail	-0.0679	-0.0645	-0.0553	0.0831 °	0.0275	-0.0854 °	0.0367	-0.0292	-0.0714	-0.0826 °
Prix Kiosque	0.1743 *	-0.0973	0.0236	-0.0362	0.0928	0.0869	-0.1212	0.0723	/	/
Prix village	0.2006 **	-0.0337	-0.0687	0.1578 *	0.0625	0.0682	-0.0260	0.0232	/	/
Combien fois au kiosque	-0.0193	0.1140	-0.1702	0.0303	0.0387	-0.0067	-0.0680	-0.0713	/	/
Combien fois au village	0.0834	-0.0735	-0.2294 **	0.2321 ***	0.0159	-0.3224	0.0147	0.0910	/	/
Combien fois platte	0.0825 °	0.0063	0.0097	0.0213	-0.0367	-0.1601 ***	-0.0087	0.0659	0.1684 ***	0.0171
Prix 1	0.1716 ***	-0.1909 ***	-0.1130 °	-0.0301	0.0094	-0.0722	-0.0365	0.0516	0.0753	0.1399 **
Prix 1 + Y	0.1122 *	0.1356 **	0.1088	-0.0469	0.0003	0.1699 ***	-0.0295	-0.0052	-0.0193	-0.0895
Prix 1 – Y	0.0617	-0.2091 **	0.0028	-0.1321	-0.0295	0.1631 °	-0.0389	0.0387	-0.1410	0.1003
Prix 2	0.1933 ***	-0.1984 ***	-0.1305 *	-0.0066	-0.0165	-0.0391	-0.0748	0.0447	0.0022	0.1590 ***
Prix 2 + Y	0.1080 *	0.1127 *	0.0801	-0.0741	-0.0204	0.1485 **	0.0006	-0.0197	-0.0222	-0.0146
Prix 2 – Y	0.1334	-0.2315 **	0.0559	-0.1150	0.0056	0.1508 °	-0.0188	0.0734	-0.1733 °	0.0841
Prix 3	0.1814 ***	-0.1547 ***	-0.0853	0.0278	-0.0313	0.0468	-0.0638	0.0748	0.0865 °	0.1311 **
Prix 3 + Y	0.0936 °	0.0972 °	0.0620	-0.1154 *	-0.0144	0.1346 **	-0.0084	-0.0551	0.0020	-0.0626
Prix 3 - Y	0.0220	-0.0819	0.0805	-0.0824	-0.1549 °	0.3325 ***	-0.0818	-0.0714	-0.1979 *	0.0217
Option préféré	-0.0260	-0.0512	-0.1578 **	0.1199 **	0.0316	0.0206	0.0119	-0.0087	0.0103	-0.1038 *

Significances: *** 0.01; ** 0.05; * 0.10; ° 0.15

Table 10 (continues): Correlation table

	Charger au village	Charger au kiosque	Charger au travail	Prix Kiosque	Prix village	Combien fois au kiosque	Combien fois au village	Combien fois platte
PersonneFamille								
AgeEnquete								
AgeCM								
Televion								
Radio								
Lampes								
Frigo								
Combien Portables								
Charger à la maison								
Charger chez des amis								
Charger au village	1							
Charger au kiosque	-0.5857 ***	1						
Charger au travail	-0.1468 ***	-0.1193 **	1					
Prix Kiosque	-0.0693	/	-0.0693	1				
Prix village	/	-0.0708	-0.1004	/	1			
Combien fois au kiosque	-0.0388	/	0.2064 **	0.1142	/	1		
Combien fois au village	/	-0.1226 °	-0.0345	/	0.1856 **	/	1	
Combien fois platte	-0.1855 ***	0.0795 °	0.0749	-0.2830 ***	0.1161	-0.0286	0.3314 ***	1
Prix 1	0.1828 ***	-0.3168 ***	-0.0202	0.1607 °	-0.0568	0.0046	-0.2149 ***	-0.0948 *
Prix 1 + Y	0.1082 *	-0.0088	-0.0634	-0.0199	-0.1129	-0.1447	-0.0891	-0.0459
Prix 1 - Y	-0.2029 *	0.1582 °	0.1128	0.0680	-0.1864	-0.0501	0.0367	-0.0436
Prix 2	0.2048 ***	-0.3224 ***	0.0100	0.1607 °	-0.0529	0.0046	-0.0746	-0.1118 **
Prix 2 + Y	0.0295	0.0311	-0.0334	-0.0513	-0.1645 *	-0.1647	-0.1450 °	0.0599
Prix 2 - Y	-0.1193	0.1363	0.0977	0.0680	-0.0225	-0.0501	0.0398	-0.1331
Prix 3	0.1349 **	-0.2695 ***	-0.0107	0.1897 *	-0.0351	-0.0030	-0.2738 ***	-0.1478 ***
Prix 3 + Y	0.0776	0.0121	-0.1086 *	-0.0279	-0.1405 °	-0.1722	0.0305	0.0468
Prix 3 - Y	-0.2103 **	0.2196 **	0.0217	0.0849	0.1840	-0.0257	0.1017	-0.0221
Option préféré	-0.0644	0.1028 *	0.0944 *	0.0153	0.0153	0.1258	-0.0992	0.0246

Significances: *** 0.01; ** 0.05; * 0.10; ° 0.15

Table 10 (continues): Correlation table

	Prix 1	Prix 1 + Y	Prix 1 - Y	Prix 2	Prix 2 + Y	Prix 2 - Y	Prix 3	Prix 3 + Y	Prix 3 - Y	option préféré
PersonneFamille										
AgeEnquete										
AgeCM										
Televion										
Radio										
Lampes										
Frigo										
Combien Portables										
Charger à la maison										
Charger chez des amis										
Charger au village										
Charger au kiosque										
Charger au travail										
Prix Kiosque										
Prix village										
Combien fois au kiosque										
Combien fois au village										
Combien fois platte										
Prix 1	1									
Prix 1 + Y	/	1								
Prix 1 - Y	/	/	1							
Prix 2	0.8910 ***	0.0778	0.1416	1						
Prix 2 + Y	0.0896	0.9188 ***	/	/	1					
Prix 2 - Y	0.0206	0.2582	0.8495 ***	/	/	1				
Prix 3	0.7813 ***	0.1444 **	0.0122	0.8308 ***	0.1289 **	0.0367	1			
Prix 3 + Y	0.1257 **	0.8532 ***	0.2582	0.0558	0.8821 ***	0.2928	/	1		
Prix 3 - Y	-0.3713 ***	-0.2676	0.8754 ***	-0.2556 ***	0.0000	0.8491 ***	/	/	1	
Option préféré	-0.0600	0.0228	0.0495	-0.0893 *	0.0375	0.0713	0.0153	0.0095	0.0810	1

13.4 Appendix 4: Business model for the large battery (for engineering students)

Cette appendice comprise deux options pour le modèle d'affaires pour la grande batterie à Sichem.

13.4.1 Option 1

Ici, la première option est décrite pour le modèle d'affaires pour la grande batterie, aussi appelé un *powerbank*, qui est prévue par les ingénieurs pour Sichem. Il s'agit de deux batteries qui peuvent charger 40 portables et une batterie peut être rechargé 300 fois avant de casser. La batterie est utilisée dans un système de kiosque : elle est placée dans un village pour une journée et les gens peuvent venir pour charger leurs portables. Chaque jour, un autre village est choisi, donc chaque semaine, les cinq villages interrogés sont visitées. En conséquence, les batteries sont un substitut pour les autres moyens utilisé maintenant pour charger des portables. Les batteries sont différents des autres moyens parce qu'ils sont plus durable, mieux adapter aux temps avec une qualité meilleure et ils viennent de Sichem. Les clients de ce système sons donc des familles dans cinq différents villages : Dzogblakopé, Hagblévou, Kétapui, Abolavé et Adidomé. Surtout les familles le plus pauvre sont visées puisque un chargement de portable a le but d'être moins chère que dans un kiosque par exemple. Chaque jour, un responsable est présent dans un village avec une batterie et il prend en charge la « vente » des chargements des portables. Cette personne est aussi responsable pour charger la batterie à Sichem et pour maintenir l'installation en état. La monnaie que Sichem gagne avec la vente peut être utilisée pour le salaire de cette personne et pour les réparations. Si la batterie est cassée à cause de plus de chargement qu'il n'en faut, une nouvelle batterie doit être achetée avec le profit fait. Pour Sichem, ONG Togo Debout et ONG SEA sont des partenaires très importants vu qu'ils paient l'investissement initial. Les deux étudiants, Kaz et Daan, sont aussi très important puisqu'ils construisent l'installation avec des panneaux solaires et la batterie pour l'innovation implémenter dans les villages et en plus, ils forment les gens concernant le fonctionner de l'installation. Evidemment, introduire un tel système vient avec des revenus et des coûts et les flux de trésorerie sont calculés dans l'appendice suivant.

13.4.2 Option 2

Ici, la deuxième option est décrite pour le modèle d'affaires pour la grande batterie. Il s'agit de nouveau de deux batteries qui peuvent charger 40 portables et la batterie peut être rechargé 300 fois avant de casser. Au lieu d'être utilisée dans un système de kiosque, les batteries restent à Sichem tout le temps et les gens peuvent venir pour charger leurs portables. Les batteries sont encore un substitut pour les autres moyens utilisé maintenant pour charger des portables. Les batteries sont différents des autres moyens parce qu'ils sont plus durable, mieux adapter aux temps avec une qualité meilleure et ils viennent de Sichem. Les clients de ce système sont donc des familles dans des villages autour de Sichem. Surtout les familles le plus pauvre sont visées puisque un chargement de portable est moins cher avec la batterie de Sichem que dans un kiosque par exemple. Chaque jour, la « vente » se passe à la bibliothèque de Sichem. Dans la bibliothèque, il y a déjà quelqu'un pour charger les crédits des portables, donc ce n'est pas nécessaire de recruter quelqu'un d'autre pour prendre en charge la vente. Seulement la maintenance de l'installation doit être faite par une personne. La maintenance prend au maximum un (1) jour par semaine, donc le salaire n'est pas assez haut que dans option 1. Par mois, la maintenance est estimée de prendre trois jours et le salaire est donc entre 15.000 CFA et 25.000 CFA par trois mois. La monnaie que Sichem gagne avec la vente peut être utilisée pour le salaire de cette personne et pour les réparations. Si la batterie est cassée à cause de plus de chargement qu'il n'en faut, une nouvelle batterie doit être achetée avec le profit fait. Pour Sichem, ONG Togo Debout et ONG SEA sont des partenaires très importants vu qu'ils paient l'investissement initial. Les deux étudiants, Kaz et Daan, sont aussi très important puisqu'ils construisent l'installation avec des panneaux solaires et la batterie pour l'innovation implémentée dans les villages et en plus, ils forment les gens concernant le fonctionner de l'installation. Evidemment, introduire un tel système vient avec des revenus et des coûts et les flux de trésorerie sont calculés dans l'appendice suivant.

13.5 Appendix 5: Cash flows of the large battery (for the engineering students)

Comme expliquer dans chapitre 9, les coûts de l'installation ne sont pas attribuables au système des batteries et pour ça, je n'ai pas inclus les coûts dans les calculs suivants. Seulement les coûts de l'installation pour les batteries sont inclus dans le calcul au-dessous. Il y a seulement des coûts fixes. Dans la thèse, les powerbank sont chargés avec le net, mais ici, les batteries sont chargées avec l'installation solaire. Le prix pour un seul chargement est calculé pour être égale aux coûts par chargement. Comme ça, le seuil de rentabilité est trouvé.

Table 11: Coûts différents pour les deux modèles d'affaires

	Option 1		**Option 2**	
	Totale	Par chargement	Totale	Par chargement
Coûts fixes	**9.340.500**	**59,88**	**3.340.500**	**21,41**
Coûts installation batteries	645.500	4,14	645.500	4,14
Batteries	1.495.000	9,58	1.495.000	9,58
Salaire maintenance	7.200.000	46,15	1.200.000	7,69
COUTS TOTAUX	**9.340.500**	**59,88**	**3.340.500**	**21,41**
Coûts totaux en euro	14.260	0,09	5.100	0,03
REVENUS	**9.340.500**	**59,88**	**3.340.500**	**21,41**
PROFIT	0	0	0	0

Table 11 indique que le prix d'option 2 est le plus bas (21,41 CFA contre 59,88 CFA) et ainsi, option 2 est préférée. La grande différence entre les coûts des deux options est le salaire de l'employée pour la maintenance. Option 2 demande seulement quelqu'un pour maintenir l'installation en état, mais option 1 a besoin de quelqu'un pour accompagner la batterie dans les villages chaque jour. Option 1 demande donc un salaire de 40.000 CFA par mois et option 2 seulement 20.000 CFA par trois mois. Comme ça, c'est possible pour Sichem de demander 25 CFA pour un seul chargement d'une portable à la bibliothèque. Les utilisateurs de cette batterie peuvent économiser au moins 20 CFA par chargement et Sichem peuvent réaliser un bénéfice de 559.500 CFA pendant les 15 ans. Personnellement, moi je conseille Sichem d'introduire le model d'affaires d'option 2.

Si option 1 est préféré, on doit demander un prix de 60 CFA. Malheureusement, le prix de 60 CFA est plus haut que le prix dans les kiosques donc la valeur de ces batteries diminue.

13.6 Appendix 6: Cost difference allocation powerbank investment costs

Table 12: Difference in costs with allocation powerbank costs

	Without installation costs		**With all investment costs**	
	Total	Per rental	Total	Per rental
Fixed costs	**6,955,400**	**1,159**	**9,834,676**	**1,639**
Installation costs Belgium	0	0	2,146,776	358
Installation costs Togo	0	0	732,500	122
Powerbank costs Togo	630,400	105	630,400	105
Powerbanks themselves	5,125,000	854	5,125,000	854
Wage maintenance	1,200,000	200	1,200,000	200
Variable costs	**2,160,000**	**360**	**2,160,000**	**360**
Charging powerbanks	2,160,000	360	2,160,000	360
TOTAL COSTS	**9,115,400**	**1,519**	**11,994,676**	**1,999**
Total costs in euro	13,916.64	2.32	18,312.48	3.05
REVENUES	**9,115,400**	**1,519**	**11,994,676**	**1,999**
PROFIT	**0**	**0**	**0**	**0**

This table shows the costs when the investments made for the powerbanks are mentioned separately and also allocated to the powerbank rentals. It increases the costs slightly (with 105) compared to the costs mentioned in chapter 9. However, the profit made on one rental is approximately 1,000 CFA, which is enough to cover up for this slight increase in costs.

Auteursrechtelijke overeenkomst

Ik/wij verlenen het wereldwijde auteursrecht voor de ingediende eindverhandeling:
An optimal business model for a new energy innovation in the Sichem centre in Dzogblakopé Lomé (Togo)

Richting: **master in de toegepaste economische wetenschappen: handelsingenieur-technologie-, innovatie- en milieumanagement**
Jaar: **2018**

in alle mogelijke mediaformaten, - bestaande en in de toekomst te ontwikkelen - , aan de Universiteit Hasselt.

Niet tegenstaand deze toekenning van het auteursrecht aan de Universiteit Hasselt behoud ik als auteur het recht om de eindverhandeling, - in zijn geheel of gedeeltelijk -, vrij te reproduceren, (her)publiceren of distribueren zonder de toelating te moeten verkrijgen van de Universiteit Hasselt.

Ik bevestig dat de eindverhandeling mijn origineel werk is, en dat ik het recht heb om de rechten te verlenen die in deze overeenkomst worden beschreven. Ik verklaar tevens dat de eindverhandeling, naar mijn weten, het auteursrecht van anderen niet overtreedt.

Ik verklaar tevens dat ik voor het materiaal in de eindverhandeling dat beschermd wordt door het auteursrecht, de nodige toelatingen heb verkregen zodat ik deze ook aan de Universiteit Hasselt kan overdragen en dat dit duidelijk in de tekst en inhoud van de eindverhandeling werd genotificeerd.

Universiteit Hasselt zal mij als auteur(s) van de eindverhandeling identificeren en zal geen wijzigingen aanbrengen aan de eindverhandeling, uitgezonderd deze toegelaten door deze overeenkomst.

Voor akkoord,

Van Welde, Lore

Datum: **28/05/2018**