Augmenting the diffusion of solar home systems for rural electrification : An Indian perspective

TU Delft Delft University of Technology

Gaurav Manchanda
MSc Sustainable Energy Technology

The cover page story

The cover picture has a special significance in this project. It represents a solar panel mounted on the roof of the rural household partially covered by cow dung cakes which are being dried in the sun. These cakes will be used as a cooking fuel once they are completely dried. The reader can also see the power grid lines running over these rural households. It is ironic that this rural household is not connected to the grid whereas the grid has lasted for decades.

Cover: Solar Home System, Bajhera Village, Aligarh, Uttar Pradesh, India
Photo Credits: Gaurav Manchanda

This manuscript is designed for double-sided printing

Disclaimer: All the information in this report is for academic purpose only. The information collected during the interviews have been expressed to the best knowledge of the author. All the analysis performed is done by the author.

Augmenting the diffusion of solar home systems for rural electrification

An Indian perspective

By
Gaurav Manchanda

in partial fulfilment of the requirements for the degree of

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Graduation Committee
Dr. L.M.(Linda) Kamp
Dr. J.R.(Roland) Ortt
Prof.dr.C.P.(Cees) van Beers

TU Delft

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“We will make electricity so cheap that only the rich will burn candles” ~ Thomas A. Edison

Edison’s words of knowledge back in 1880 devised electricity to reach the poorest of poor, but eventually that never happened. Still, in a developing country like India, 300 million people do not have access to electricity.

***Keywords*:** barriers, strategies, business model canvas (BMC), solar home system (SHS), key partners, key resources, value proposition, cost structure, revenue streams, customer relationships, customer segments, channels, key activities

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Executive Summary

The electricity situation is currently unacceptable where millions of households are either un-electrified or underserved by the central electricity grid. People are suffering from a multitude of socio-economic problems which includes poverty, weak education, poor health and low spending incomes. People in the rural areas still depend on conventional sources of energy such as wood and kerosene for cooking and lighting purposes. They do not realize the risk of burning kerosene and wood which causes numerous health problems. There are many renewable energy solutions possible to supply electricity to the rural populace. One of the most efficient and feasible solutions is via solar energy. The use of solar home systems which is an off-grid solution is rapidly increasing. It has impacted the lives of the people both socially and economically. Children can now study in the dark with the help of lights powered by a solar home system, women can cook in the late hours, and the local shops can run till late in the evening. The use of such systems has reduced health problems and improved the lifestyle and aspirations of people. Multiple companies are offering such off-grid solutions in India and other developing countries. These are Simpa Networks, SELCO, Boond, D-light, ONergy, Rural Spark, Philips and many others. However, these companies face several barriers during the implementation process which has dampened the diffusion of the products offered by them. The need for a sustainable business model is felt in this sector to scale up the market.

The objective of this research is to augment the diffusion of solar home systems for rural electrification in India. The main research question to be answered in this project is *"How can we maximize successful penetration of solar home systems for rural electrification?"* To answer this question, the research is divided into two major steps. The initial stage of the *first* step is an extensive review of literature to identify barriers and strategies for diffusion of renewable energy products and particularly solar home system in developing countries. The basis of the study is the literature contribution of "Ten niche strategies to commercialize new high-tech products" by Ortt *et al.* This framework is studied and adapted according to the relevant literature on diffusion of renewable energy products, particularly solar home systems in developing countries. The second stage of this step is the linkage between strategies in the adapted framework and elements of the business model canvas. The business model canvas theory is given by Osterwalder *et al.* and is used to frame linkages with niche strategies.

The *second* step of the research method is to adapt the framework and gain practical insights through three case studies, additional expert interviews, and field study in rural parts of India. These case studies are primarily based on expert interviews conducted for Simpa Networks, Rural Spark, and Philips. Simpa Networks is based out in the northern state of Uttar Pradesh, Rural Spark has its operations in Uttar Pradesh and Bihar and Philips has PAN India operations. The most important barriers identified from the interviews are *lack of awareness, un-affordability, lack of skilled personnel, lack of financial resources for the end-consumer, lack of availability of solar home systems, increased market competition and rapid grid extension & greater reliability*. The strategies identified are *access to finance for the end consumer, participation niche strategy where the local heads or influential people in the village act as ambassadors for the company, educate niche strategy to create awareness among the people, leveraging the existing distribution network to increase the customer reach, access to financial resources for the company and research & development into the product*. The field study is carried out in collaboration with Simpa Networks in the Aligarh district of Uttar Pradesh, India. This field visit is relevant in terms of conducting multiple stakeholder interviews and in understanding the barrier-strategy sets and their linkage with the business model canvas elements. The main findings of the field visit are briefly discussed here. Rapid electrification and increased reliability of the mains grid has resulted in decline of the product sales and has been stressed by multiple stakeholders. Another challenge is the presence of severe market competition from the Chinese products which has disrupted the market. With respect to the strategies, the importance of the sales and service team was realized during the customer visits made with them. This helped in understanding the effect of service and maintenance strategy on the BMC elements explicitly. The service team plays an important role in maintaining the system and building ***customer relationship***. The other ***key activity*** performed by them is the payment collection which ensures the ***revenue streams*** are not blocked.

An important research area for this project is to understand the relationship between barriers, strategies and elements of the business model canvas. A business model canvas (BMC) is a tool to design a business model in the form of nine key elements which are *key partners, key activities, key resources, value propositions, customer relationship, customer segments, revenue streams, channels* and *cost structure*. The outcomes of this project are the linkages between strategies and BMC elements which is illustrated below for the **access to finance strategy**. The ***value proposition*** is strengthened as the company is offering an attractive offer to the end consumer. The ***customer segments*** rise with the availability of finance, and hence the ***revenue streams*** are also enhanced. The company builds several ***key partners*** in the form of microfinance institutions and self-help groups who provide finance to consumers. The **access to finance** for companies is also important as it allows smoother operations and helps the company to perform ***key activities*** with ease. The ***key partners*** are international funding organizations and investors, mainstream banks and development finance institutions who provide financial resources to the company. These financial instruments are added up as ***key resources***. Essentially, the business model canvas is used as a tool to understand the effect of strategies. This exercise is indeed helpful in evaluating the business model and reflecting upon its elements.

The outcomes of the barriers and strategies adaptation are discussed below. The original framework by Ortt *et al.* consists of six influencing factors and six core factors and a list of ten niche strategies for different market situations. In the adapted framework, ***five influencing factors have been added*** which are *affordability, infrastructure, environmental, political and business knowledge*. ***Three core factors have been added*** which are *consumer awareness and risk perception, lack of financial resources and market competition*. The adapted core & influencing factors with an enriched description are production system, natural resources, socio-cultural aspects, complimentary products & services and institutional aspects. The definition of suppliers is made clearer whereas in the new high-tech product factor, cost comes out to be the most important element. ***Five niche strategies have been added*** to the original framework. These are *access to finance, lobbying, participation niche strategy, environmental measures and service & maintenance*. The original strategies are slightly adapted in the conclusive framework.

The contribution of this research to science is the linkage between strategies and the business model canvas elements. The BMC is used as an analysis tool to understand the effect of strategies explicitly. The implications of strategies on the business model canvas are identified for each element. Another scientific contribution of this research is the adaptation of Ortt *et al.* framework which can now be used for the diffusion of solar home systems in a developing country like India whereas the original Ortt *et al.* framework can be used only for diffusion of high-tech products in the developed nations. From the market perspective, this research identifies barriers & strategies relevant for rural electrification in the BoP segment. The linkage between the BMC and strategies offers a tool to understand and evaluate the strategies. It allows the market players to make strategic decisions on the implementation of their ideas by considering the implications of different strategies on the elements of BMC. For instance, if a company wants to implement the "*participation niche strategy*", it can refer to this tool and understand its implications on the business model.

The future scope of research in this field has multiple dimensions to offer. Firstly, the relationship between barriers, strategies and business model elements can be further explored as the business model canvas can be used to explicitly define the strategies and enrich their meaning. Secondly, future research can be carried out to understand the barriers faced and strategies employed by the key partners to the focal company and its implications on the focal company's business model canvas. Thirdly, a qualitative and quantitative analysis can be performed on the strategy-BMC linkage matrix. This will give a richer meaning to the implications by assessing the level of importance for each implication. Another dimension is to create a comprehensive business model from the strategy-BMC linkages through which each element of the business model is enriched. This research can also be carried out for other renewable energy technologies across various geographies. Also, within the current project, the scope of research can be broadened to numerous case studies and field visits in multiple locations to strengthen the framework.

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Gaurav Manchanda
Delft, The Netherlands

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Abbreviations used

ABM	Area Branch Manager	MPPT	Maximum Power Point Tracking
AC	Alternating Current	NBFC	Non-Banking Financial Company
ADB	Asian Development Bank	NGO	Non-governmental organization
BMC	Business Model Canvas	PAYG	Pay-as-you-go
BoP	Base of Pyramid	PRE	Power Research Electronics
C$	Cost Structure	PV	Photo-voltaic
CAF	Customer Application Form	PWM	Pulse Width Modulation
CCU	Charge Controller Unit	R$	Revenue Streams
CEO	Chief Executive Officer	R&D	Research & Development
CH	Channels	RBL	Ratnakar Bank Limited
CR	Customer Relationship	REC	Rural Electrification Corporation
CRA	Customer Relationship Associate	RHH	Rural Household
CRO	Customer Relationship Officer	RS	Rural Spark
CS	Customer Segments	RSA	Rural Sales Associate
CSR	Corporate Social Responsibility	SHG	Self-help group
DC	Direct Current	SHS	Solar Home Systems
DRES	Decentralized Renewable Energy Systems	SME	Small and medium sized enterprise
ICT	Information & Communications Technology	STOF	Service Technology Organization Finance
JNSM	Jawaharlal Nehru National Solar Mission	TCO	Transparent Conduction Oxide
KA	Key Activities	TCP	Training Certificate Program
KP	Key Partners	TERI	The Energy & Resources Institute
KR	Key Resources	UM	Urja Mitra
LED	Light Emitting Diode	UP	Uttar Pradesh
LIC	Life Insurance Company	USP	Unique Selling Point
LSE	Local Energy Supplier	VLE	Village Level Entrepreneur
MFI	Micro-finance institution	VP	Value Proposition

CHAPTER 1: INTRODUCTION

1. Introduction

1.1. Introduction

More than a billion people in the world do not have access to electricity and are suffering both socially and economically (Mathur *et al.* 2015). There is minimal economic development in the regions without electricity.

There are multiple social problems associated with it such as lower level of education, poor health and increasing poverty (United Nations Department of Economic and Social Affairs 2014). The electricity situation in developing countries like India is indigent as millions of households are un-electrified and not served by the central electricity grid (Mural *et al.*, 2015). People living in these areas still depend on inefficient and conventional sources of energy such as wood and kerosene (International Energy Agency 2015).

To overcome this problem of acute un-electrification, there are multiple applications of renewable energy systems such as solar lanterns, solar cookers, solar home systems (photovoltaic based), family type biogas plants, improved biomass cook stoves, solar water pumps for irrigation and several more. In this project, the focus is on the adoption of solar home systems for rural electrification, however it might be expected that SHS is not a sufficient technology alone. The various renewable energy systems as mentioned above might complement these SHS's and justify the local electricity needs. A SHS is a system comprising of a PV module, a charge controller, battery, balance of system (cables, switches, plugs) and devices running on such system such as lights, television, radio, etc.

Despite the advancements in technology and financial attractiveness for several renewable energy systems, there have been significant barriers to the adoption of these technologies. These barriers need to be identified and possible measures to be taken to realize the full potential of these technologies (Luthra *et al.* 2015). Inadequate financial wealth, limited infrastructure, scarce availability of resources in rural areas and shallow government policies are major bottlenecks towards providing electricity (Younger 2011).

There are multiple companies in India who aim to provide electricity via decentralized renewable energy systems to the underserved and off-grid rural areas. These companies include Simpa Networks, Orb Energy, SELCO, Boond which are providing electricity via solar home systems. The barriers as discussed above affect the company's business model in different ways. The business model is comprised of several elements as described by Osterwalder *et al.* These elements are customer segments, value proposition, channels, customer relationships, revenue streams, key resources, key activities, key partnerships and cost structure.

Therefore, to solve the problem of acute un-electrification and successful diffusion of solar home systems for rural electrification, it is pertinent to study these barriers in depth to understand the situation. Also, for better grasp and understanding of the business model, the barriers and corresponding strategies can be linked to its elements.

1.2. Background

1.2.1. About India

India is one of the oldest civilizations in the world spreading across 3.3 million sq.km with a population of 1.3 billion making it the world's largest democracy. India is seventh largest by area and the second most populous country after China. The Indian peninsula is covered by the Himalayas in the north, surrounded by the Bay of Bengal in the east, the Arabian Sea in the west and the Indian Ocean in the south.

The official language of India is Hindi, and there are 22 different languages which have been recognized by the constitution of India. The constitution of India provides by law for the continued use of English for official purposes. Hindus comprise most the population followed by Muslims, Sikhs, Christians, Buddhists, Jains and others. The capital of the country is New Delhi which lies in the northern part of India. India is divided into 29 states and 7 union territories.

India got its independence from the British rule on August 15, 1947. The country is led by a parliamentary system of government. The government is currently led by Narendra Modi who is the current Prime Minister of India. The President of India who is the Head of State and Commander-in-chief of the Indian Armed Forces is Shri Pranab Mukherjee. The Supreme Court of India is the apex judicial body followed by High Courts and subordinate courts.

The iconic Taj Mahal, one of the seven wonders of the world, is a white marble mausoleum situated in the city of Agra, India. The notable noble prize winners from India are Rabindranath Tagore (literature), CV Raman (physics), Mother Teresa (peace), Amartya Sen (economics) and Kailash Satyarthi (peace).

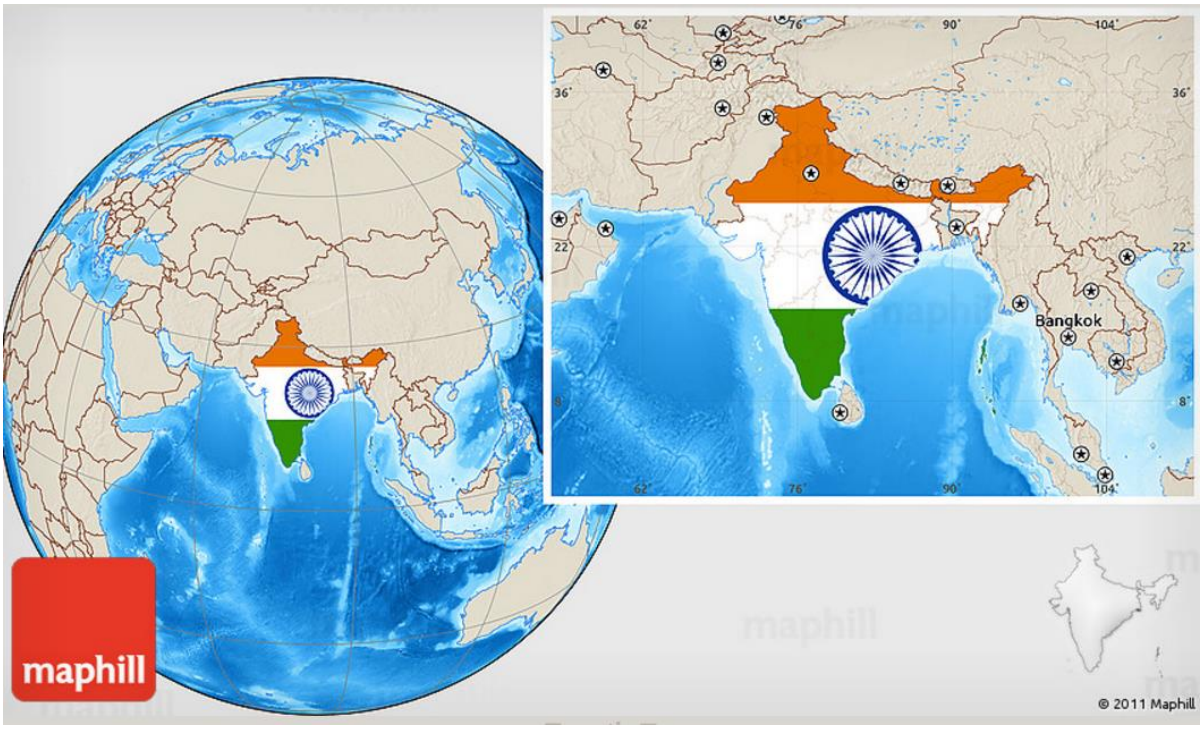

Figure 1-1 India on a world map (maphill n.d.)

1.2.2. Rural household electrification in India

According to the Indian government's RHH (rural household) electrification portal, 29% of the rural households in India which are more than 50 million in number do not have access to electricity. To highlight this problem, let us consider the state of Uttar Pradesh, where the rural household electrification rate is just 47% (REC 2017). In the same region, a considerable amount of population is under-served by the electricity grid receiving less than four hours of electricity per day (The Climate Group 2013). The map below indicates the northern state of Uttar Pradesh in India. The total area of this state is 240,928 sq km with a population of around 200 million (Government of UP 2011). This state is almost six times larger than The Netherlands in terms of area and approximately twelve times in terms of population.

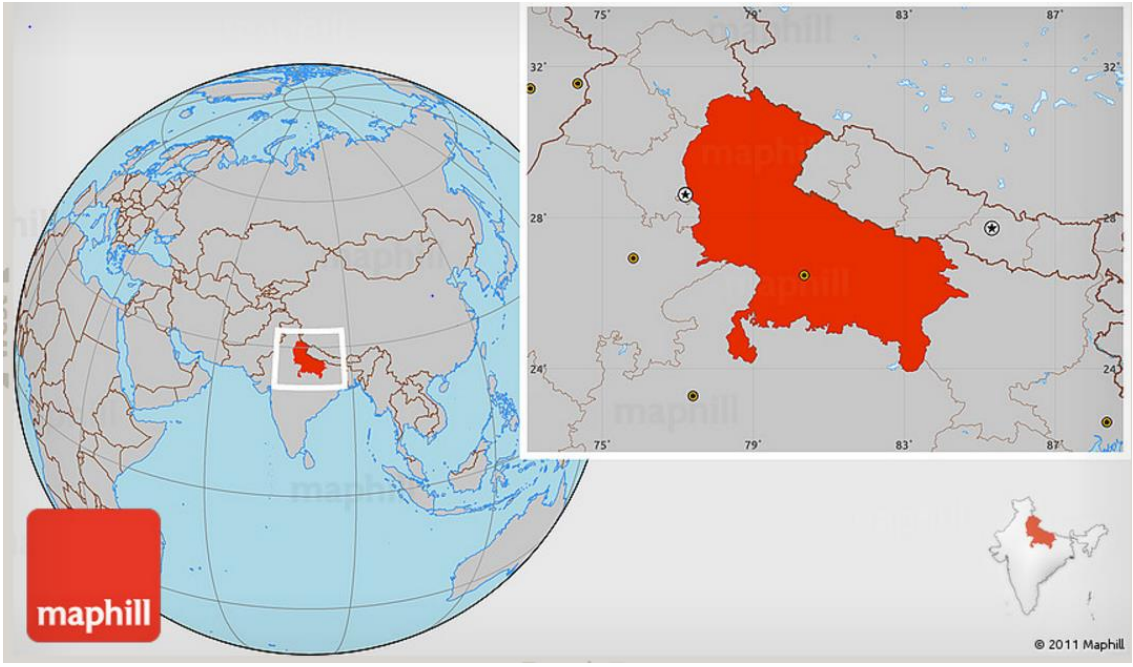

Figure 1-2 The northern state of Uttar Pradesh in India on a global scale (maphill n.d.)

1.2.3. Role of renewable energy for rural electrification

The rural households are being electrified worldwide by the use of renewable energy systems which are generally classified into centralized and decentralized renewable energy systems. The DRES's (decentralized renewable energy systems) such as a solar lantern, solar home systems, family type biogas plants, improved biomass stoves, etc. are regarded as an efficient solution to electrify remote households which are not being served by the central electricity grid due to technical or financial constraints. However, these DRES's face several barriers such as technical, economic, regulatory or institutional as compared to the conventional energy systems. It is indeed essential to understand these barriers and formulate strategies to overcome them (Yaqoot *et al.* 2016).

1.2.4. Role of solar home systems

Solar home systems are viewed as an effective solution to provide electricity to rural areas of developing countries which have limited access to electricity (un-electrified and under-electrified households) (Urmee *et al.* 2016). Barman *et al.* indicated noticeable benefits with the use of solar home systems in the state of Assam, India. These benefits are less use of kerosene, extended working hours of small businesses and increase in the study hours for children (Barman *et al.* 2017). Harish *et al.* studied the conditions in Karnataka, India where even after grid electricity, the households do not hesitate to use the solar home lighting systems. This is because the grid is unreliable leading to frequent blackouts and brownouts (Harish *et al.* 2013). SHS are not only used for lighting but also related with extra income generating activities which indicate economic growth in the region (Halder & Parvez 2015). There have been multiple SHS electrification programs being implemented in developing countries but with limited success. It is, therefore, necessary to understand the critical barriers to its success and the strategies to overcome them in order to achieve successful diffusion of the technology (Urmee *et al.* 2016).

1.2.5. What are Solar Home Systems

A solar home system is adopted to electrify a single household with limited needs such as lighting, a small fan, mobile charging units and a TV. A typical solar home system comprises of a PV generator (a PV module), a charge controller and a battery. In addition to this, it consists of the appliances which are operated by this SHS which are connected by the balance of systems (cables, switches, plugs and installation material). In certain cases, an inverter is also included to operate AC appliances (Urmee *et al.* 2016)

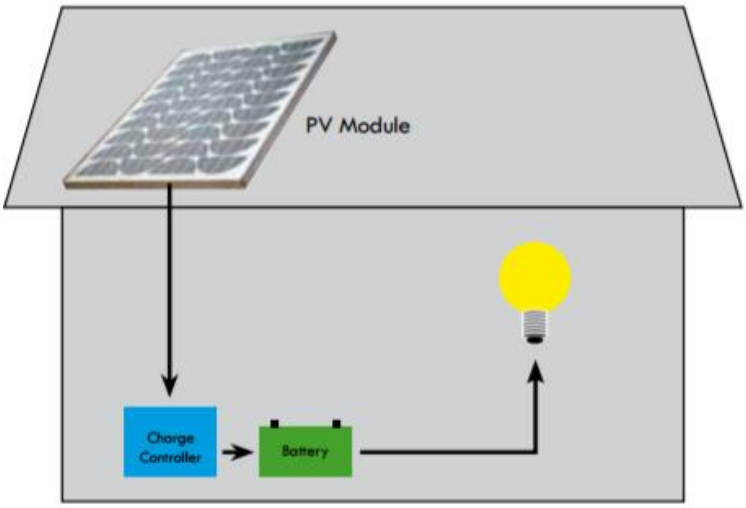

Figure 1-3 Solar home system (MicroenergyInternationalGmbH 2014)

1.2.5.1. PV Generator

A PV generator is essentially a solar panel typically ranging from 15Wp to 250Wp. The solar panel generates electricity which is stored in the battery through a charge controller unit. This energy can also be used to power small household appliances.

Generation principle

A solar cell is a p-n junction diode which converts sunlight into DC electricity using photovoltaic effect. When light (photons) are incident on the p-n junction, electron-hole pairs are generated. The photovoltaic effect is essentially a three-stage phenomenon. The solar cell generating principle is described in *figure 1-4*.

- Absorption of light - Generation of charge carriers
- Separation of charge carriers
- Collection of the carriers at the electrodes

The conversion of solar energy into electrical energy is a two-step process. The solar energy is first converted into chemical energy of electron-hole pairs then the chemical energy is converted into electrical energy.

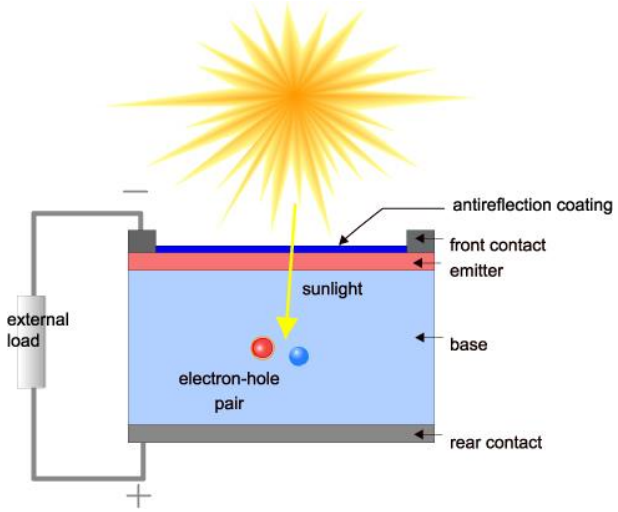

Figure 1-4 Solar cell generating principle (Solarlove 2013)

The PV technology can be generally classified into three categories which are crystalline solar cells which includes both monocrystalline and polycrystalline solar cells, thin film and third generation solar cells as shown in *figure 1-5*. The active material in crystalline solar cells is crystalline silicon with a band gap of 1.1 eV and the approximate thickness of 200µm. The thin film solar cell is a combination of amorphous with micro and nanocrystalline solar. Third generation solar cells consist of organic materials in the form of small molecules or polymer. These cells can also be manufactured from transparent conduction oxides (TCO), perovskite cells, dye-sensitized solar cell and carbon nanotubes This technology is under extensive research and striving for cost reduction. Currently, these are expensive and cannot be used in the rural markets.

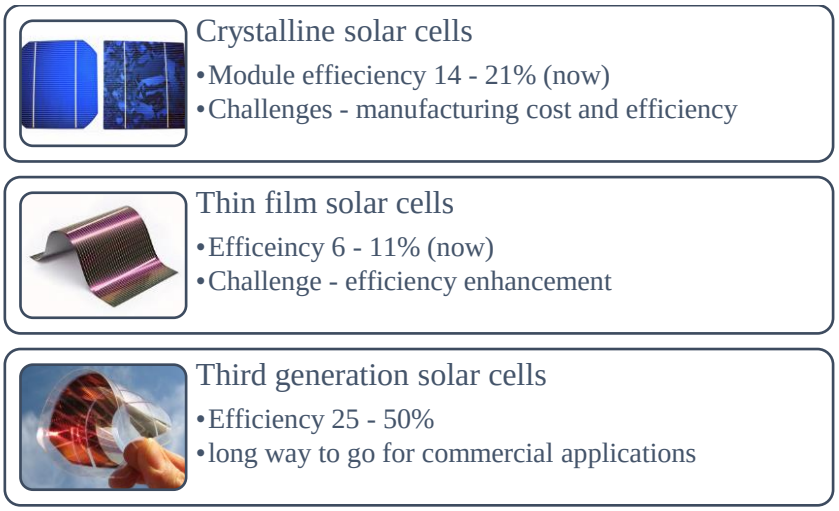

Figure 1-5 Classification of solar cell technologies (Cossio *et al.* 2012)

1.2.5.2. Energy Storage

Energy from the PV modules are stored in rechargeable batteries and is an essential part of the solar home system. Usually with all types of solar home systems, batteries are always used. They act as a backup to the system when the energy source (sun) is not available. They also act as power transformers complementing the power generated by the solar panel in the case when high amount of energy is required to power the loads. These batteries are generally categorized into lead acid batteries and lithium ion batteries. The li-ion batteries are highly efficient and lighter than the lead acid batteries but are three-four times expensive. However, the prices are coming down rapidly in the recent times. Lithium iron phosphate batteries are available which seem to perfectly fit in the solar home system. They are relatively stable, secure and efficient than other lithium chemistry battery types (Urmee *et al.* 2016). An example of Lithium iron phosphate battery is a compact 6000 mAh lithium ferro phosphate ($LiFePO_4$) battery developed by Rural Spark which has a five-year lifetime.

1.2.5.3. Charge Controllers

A charge controller regulates charge from the panel to the battery and protect the battery from over-voltage and under-voltage conditions. The charge controller also protects the appliances that are connected in a solar home system and protects the batteries from unintentional discharge by the PV panels. The state of charge in batteries is essentially regulated by these charge controllers. These charge controllers are of two types which are MPPT (maximum power point tracking) and PWM (pulse width modulated). The MPPT charge controllers are the most effective as they optimize the power point of the panel by forcing the panel to operate at its maximum power point

1.2.5.4. Appliances

The load appliances are the devices which can run on a solar home system. These generally include a DC fan, LED lights, radio, a mobile charging unit, an LED television and a small fridge. These are the basic requirements of a rural household and the system size depends upon the need and buying capacity.

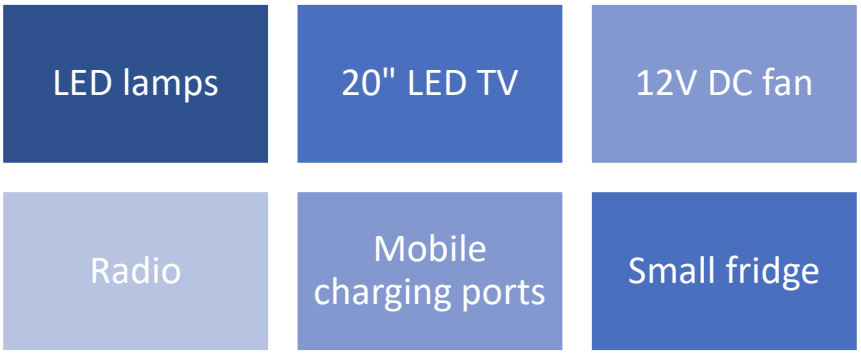

Figure 1-6 Typical appliances connected to SHS

1.2.6. Size of systems

The system sizes vary from 15 Wp to 250 Wp and battery sizes vary from 6000mAh to 200Ah as offered by different companies. These sizes vary according to the user needs for each household. *Table 1-1* and *figure 1-7* compare the system sizes for different companies in various geographies.

Table 1-1 Companies offering different SHS system sizes

Company	Operations	System size
Simpa Networks	Uttar Pradesh, India	50Wp-200Wp; 17Ah to 26Ah
Philips	PAN India	30Wp-150Wp; 20Ah to 150Ah
Rural Spark	Uttar Pradesh & Bihar, India	2 X 40Wp; 6000mAh (modular cubes)
ONergy	West Bengal, India	20Wp-200Wp; 20 to 200Ah
Kamworks	Cambodia	20Wp-100Wp
Solarnow	Uganda, Kenya	50Wp-250Wp; 45Ah to 200Ah
BBOXX	Africa	15Wp-250Wp; 7Ah to 200Ah

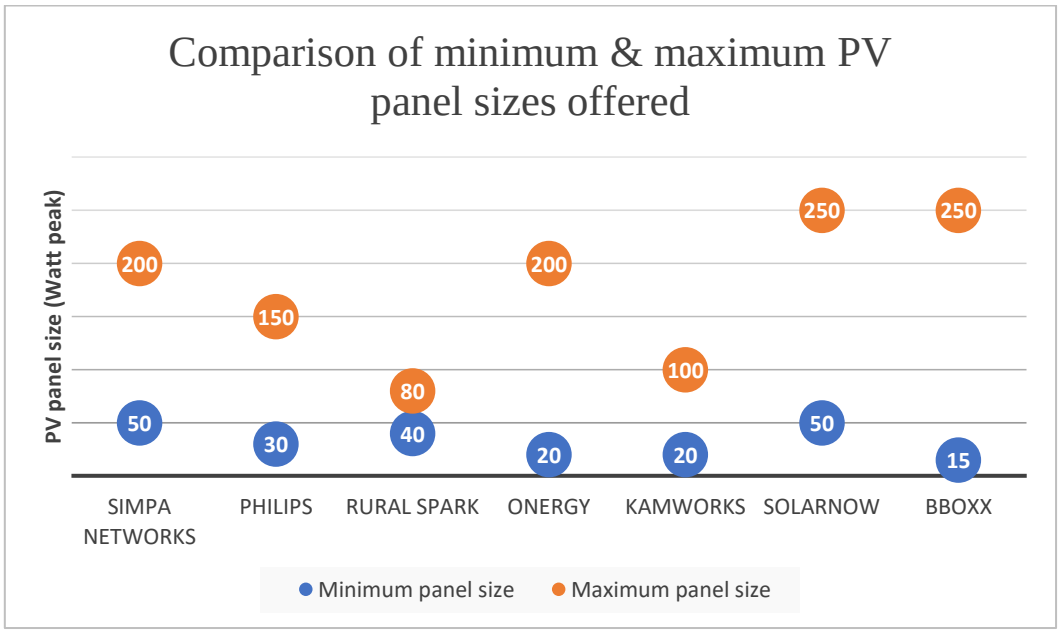

Figure 1-7 Comparison of min & max PV panel sizes for different companies

1.2.7. Solar hybrid systems

Hybrid systems in general, can consist of two or more renewable energy sources and may be coupled with conventional sources of electricity such as central grid or diesel generator as shown in *figure 1-8*. The hybrid systems can also contain storage devices such as batteries or fuel cells. The design complexity however is high and chances of failure increases. Research has been carried out to reduce the complexity and to increase the cost effectiveness of such systems Hybrid systems have been introduced in several forms most of them with solar and wind power and the capacity ranging from 500 Wp to 200kWp for solar and 400 W to 65kW for wind (Akikur *et al.* 2013).

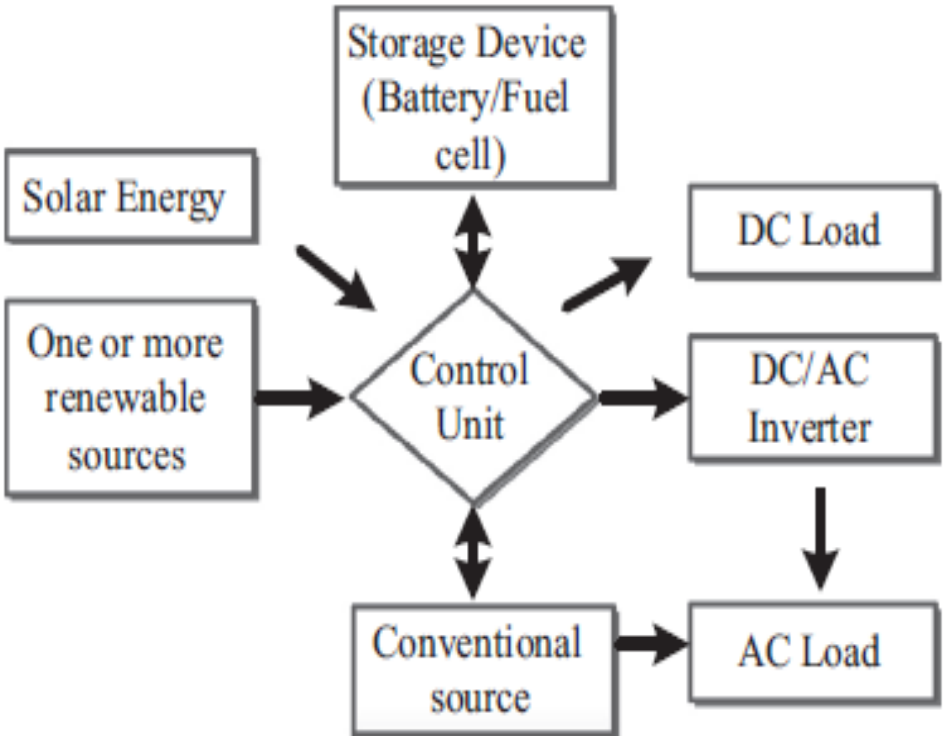

Figure 1-8 General architecture of solar hybrid systems (Akikur *et al.* 2013)

Solar home systems are now commercially available in a hybrid configuration with connectivity to the central grid and storage batteries. The batteries have an option to be recharged from two sources which are solar and grid which increases the reliability of the system. Another option available is to couple the PV panel with an existing backup system (DC/AC inverter and battery) where a controller is installed with the existing battery and the PV panel. Hence, the battery can be recharged with both the grid and PV.

1.2.8. SHS market players and business models

According to a report by The Climate Group, it is estimated that there are about 40 SHS manufacturers and distributors with an online presence in India. *Figure 1-9* maps major SHS players according to the region in which they operate. Most of these players are only 5 – 10 years old in the market and have undergone numerous iterations to their business model to reach to the present scale (The Climate Group 2013). There are several business models on which these off-grid solar enterprises perform their operations in India. These models include community managed, an entrepreneur based, pay-as-you-go model, rental and full payment service model and several others (Singh 2016).

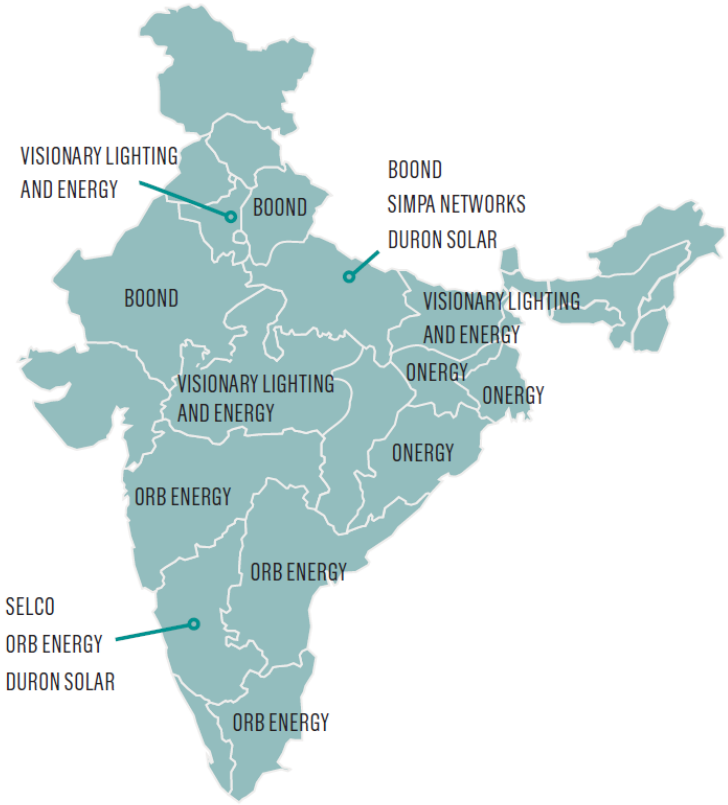

Figure 1-9 Major players in SHS market in India (The Climate Group 2013)

1.2.9. What is a business model?

The definition of a business model is evolved in the past years also focusing on it components and taxonomies. Timmers (1998) provided with one of the earliest concepts of a business model as "*a business model is an architecture for the product, service and information flows, including a description of the various business actors and their roles, a description of potential benefits for the various business actors, and a description of the sources of revenues*". Another holistic definition was provided by Osterwalder and Pigneur (2002) as "*a business model is nothing else than a description of the value a company offers to one or several segments of customers and the architecture of the firm and its network of partners for creating, marketing and delivering this value and relationship capital, in order to generate profitable and robust revenue streams.*" Bouwman *et al.* proposed a new definition after analyzing these definitions and exploring various business models as "*A business model is a blueprint for a service to be delivered, describing the service definition and the intended value for the target group, the sources of revenue, and providing an architecture for the service delivery, including a description of the resources required, and the organizational and financial arrangements between the involved business actors, including a description of their roles and the division of costs and revenues over the business actors*" (Bouwman *et al.* 2001).

Many researchers suggested on the elements or components which exist in a business model. Alt & Zimmerman (2001) proposed *mission, structure, process and revenues* as the main elements while Afuah & Tucci (2001) defined business models as a system of *components (value, revenue sources, price, related activities, implementation, capabilities and sustainability), relationships and inter-related technology*. Bouwman *et al.* focused on four domains of a business model which are *service, technology, organization and finance* and there are several components which play a role in each of these domains. This model is defined as STOF business model domains and is described below (Bouwman *et al.* 2001).

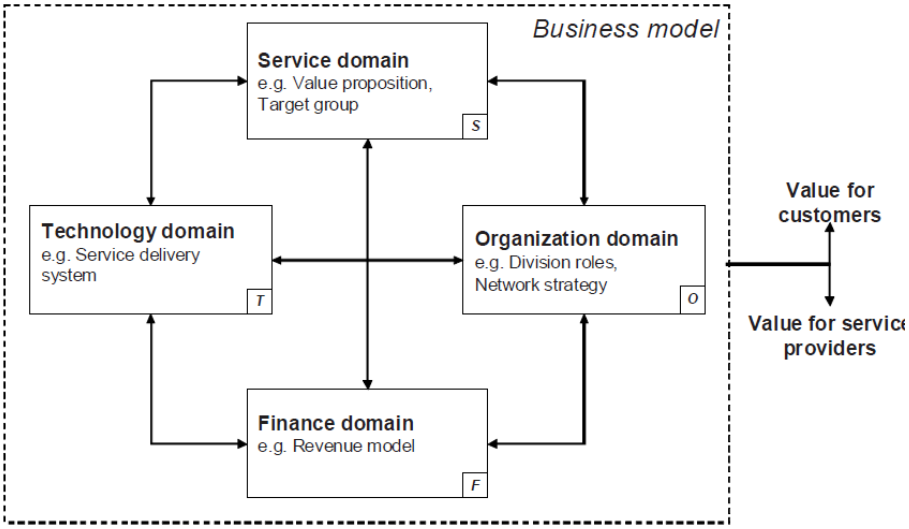

Figure 1-10 STOF business model domains (Bouwman *et al.* 2001)

Osterwalder *et al.* gave an all-inclusive model to study the components of a business model. A business model can be defined through nine basic building blocks which represent four key areas of business which are customers, offer, infrastructure and financial viability. These nine building blocks form a business model canvas which is a hands-on tool to discuss and strategize business plans. A business model canvas is described in *figure 1-11* and along with its nine building blocks (Osterwalder *et al.* 2010).

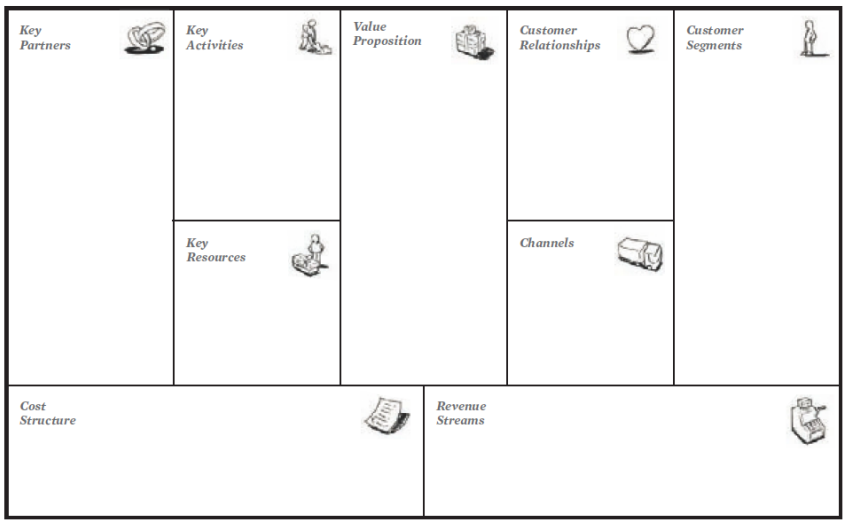

Figure 1-11 The business model canvas with nine building blocks (Osterwalder *et al.* 2010)

1.3. Identification of knowledge gaps

In the literature presented by Ortt *et al.*, the importance of niche strategies to commercialize new hi-tech products are discussed. The various actors, factors, and functions necessary for large scale diffusion of these products are presented. The linkage between different market situations and specific strategies to overcome them is also an important part of this literature (Ortt *et al.* 2013). However, this study is based on diffusion of hi-tech products in the developed world, the factors which affect the dissemination of these products in the developing nations are missing. This knowledge gap serves as an opportunity to study the barriers and strategies for the diffusion of solar home systems from the Indian perspective.

There are several companies in India which operate on different business models to serve the people with electricity in rural areas. The success of these organizations has been limited due to various factors.

Zerriffi cites a significant knowledge gap in the literature on why business models for distributed electrification fail or succeed and moreover the earlier work focusses only on success stories or best practices while neglecting the failures (Zerriffi 2007). In another article, Zerriffi states the need for innovative business models which is one of the key challenges for scaling up energy access at the bottom of the pyramid in a sustainable manner (Zerriffi 2011). For reflecting on the future outlook of these business models, the external factors or the environment needs to be carefully examined and mapped. To achieve a competitive and robust business model, the environment of the organization must be well defined and understood. The environment of any business model is classified into industry forces, key trends, market forces and macro-economic forces (Osterwalder *et al.* 2010). This business model environment addresses several factors which influence the business model. However, in the literature by Osterwalder *et al.*, the linkage between various barriers and strategies with individual elements of business model canvas is missing. Another opportunity arises here relevant to this work to study the relationship between barriers, strategies and elements of a business model canvas for SHS implementation for rural electrification. This relationship can be studied in two ways. First method is to use the business model canvas as a tool to explicitly define the strategies. This is to enrich the strategy definition which is currently meagre in nature. The second method is the use of the business model canvas tool to analyze the effect of strategies. The implications of these strategies can be studied using the elements of the business model canvas.

The literature by Ortt *et al.* and Osterwalder *et al.* present major knowledge gaps and therefore require deep research and analysis. This study attempts to fill these knowledge gaps and come up with an adapted framework for SHS implementation in India.

1.4. Objectives & deliverables

The main objectives of this project are discussed below:

- To identify barriers and strategies for renewable energy systems in developing countries.
- To review the identified barriers and strategies for the diffusion of solar home systems in India and explore the elements of business model canvas via expert interviews and case studies.
- To assess the barriers, strategies and its linkage with BMC at the grass-root level during field work in India.
- To adapt the Ortt's framework for solar home systems for rural electrification in India.
- To link the identified barriers and strategies to the business model canvas as described by Osterwalder.
- To suggest recommendations to the stakeholders for better diffusion of solar home systems.

The main deliverables of the project are discussed below:

- A framework to study the barriers and strategies for complete diffusion of SHS for rural electrification in India.
- Linkage between the business model canvas with the identified strategies for SHS deployment in the Indian rural environment.

1.5. Scientific Relevance

The project lies on two pillars which are the Ortt *et al.* framework and the business model canvas by Osterwalder *et al.* The main scientific contribution of this work is the linkage between the business model canvas and the strategies employed by the focal company. The business model canvas is used as analysis tool to understand the effect of strategies. Hence, a framework is formed where the implications of the strategies on the elements of BMC is studied. The Ortt *et al.* framework is adapted for the use of solar home systems in rural regions of India. Currently this framework is used for the diffusion of high-tech products in the developed nations. The barriers (core & influencing factors) and strategies are adapted in this framework for the diffusion of a specific product which is the solar home system for rural electrification and serves as the second scientific contribution of this research.

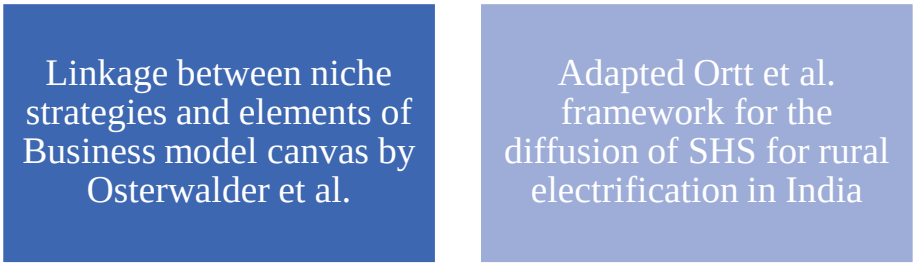

Figure 1-12 Scientific relevance

1.6. Societal Relevance

The deliverables of this project enhance the adoption and diffusion of SHS for rural electrification. The solar home systems can meet the necessary electricity requirements of the rural populace and can uplift them both socially and economically. Faster adoption of the technology would mean faster rural development for all sections of the society whereas the social impact would mean better lighting access especially for women who will be able to cook when the sun sets, and the children will get more study hours during the evening. The economic impact results in better business opportunities for both men and women thereby increasing their net wealth. This access to lighting will allow them to perform economic activities till late in the evening, for instance using the sewing machine and selling vegetables & fruits. The use of SHS also enhances security in the neighborhood.

1.7. Research Questions

How can we maximize successful penetration of solar home systems for rural electrification?

1. ***Identification of barriers***
   a) ***What are the barriers in Ortt's literature for commercializing new high-tech products?***
   b) ***How can the barriers mentioned in literature for diffusion of renewable energy products in general and solar home systems in particular be combined with the Ortt et al. framework?***

Identification of barriers is important to understand the challenges faced by the solar home systems industry in developing countries. To meet this purpose, the Ortt *et al.* framework is considered as the basis of this study. The Ortt *et al.* study describes barriers and niche strategies for high-tech products in developed nations. Within this research question, barriers are identified from developing countries literature particularly for renewable energy systems and solar home systems.

2. ***Identification of strategies***
   a) ***What are the strategies in Ortt's literature for commercializing new high-tech products?***
   b) ***How can the strategies mentioned in literature for diffusion of renewable energy products in general and solar home systems in particular be combined with the Ortt et al. framework?***

Similarly, identification of strategies is important to understand the strategies to circumvent the barriers. Several niche strategies have been identified from the Ortt *et al.* framework which forms the basis of strategy identification. The developing country literature sources have been considered for renewable energy systems in general and solar home systems in particular. This research question is also important to identify strategies for successful diffusion of solar home systems in the Indian rural market.

3. ***What are the elements of business model canvas and how are they defined?***

To build a linkage between strategies & the business model canvas (BMC) and develop a business model for the focal company, it is important to first understand the elements of the business model canvas (BMC) in detail. With this research question, the BMC elements are understood and analyzed.

4. ***What are the main barriers, strategies and business model canvas elements which are identified from the case studies and expert interviews?***

This research question is relevant to perform the case studies for companies operating in the solar home systems market. To build the strategy-BMC linkage, it is important to understand the barriers, strategies and BMC elements for various companies through case studies and expert interviews. Also, these case studies are performed to gain insights on barriers and strategies to adapt the original Ortt *et al.* framework.

5. ***What are the main findings of the field visit in terms of barriers, strategies and linkage with business model elements?***

This research question allows to understand the barriers, strategies and business model operations closely through field visit in rural parts of India by performing multiple stakeholder interviews. It is important to execute field work to analyze the situation as there might be new factors which come up which are not present in the case study interviews.

6. ***How are the general barriers and strategies in the final adapted Ortt et al. framework linked to each other?***

It is also important to understand which strategies can be used to circumvent the barriers. Therefore, with this research question, several market situations are formed by combining core and influencing factors and are linked to a particular strategy. This is another tool which helps in identifying barrier-strategy relationships and leads to successful and effective diffusion of solar home systems.

7. ***How can we link the niche strategies from the adapted framework to the elements of the business model canvas?***

This is the most important research question which contributes to the main scientific relevance of this project. The niche strategies are linked to the BMC elements to analyze the strategies with their implications on the BMC elements. These linkages also provide a tool to market players to understand the market in terms barriers & strategies and business models for successful diffusion of their products.

1.8. Research Method

The main research question for the project is "How can we maximize successful penetration of solar home systems for rural electrification" and to answer this question following research method is applied. The research methodology as per *figure 1-13* is divided majorly into two steps which is discussed in this section. The barriers and related strategies can be identified using the following approaches:

- **Literature study –** Literature study is essential for any research study as it provides a deep understanding of the subject. In this study, the Ortt's framework is used which talks about the barriers and niche strategies to commercialize new high-tech products in the developed countries. The literature sources to identify barriers and strategies particularly for implementing renewable energy technologies in developing countries are also studied.
- **Case studies –** This research method is necessary for exploring and understanding complex problems which alone cannot be solved by statistical approaches. It is considered to be a robust research method when a comprehensive and profound analysis is required (Zainal 2007). In this study, several case studies are analyzed and carried out through desk research and actor interviews for various companies.
- **Field work –** Site visits should be carried out wherever possible to understand the project closely. The data gathered can be helpful in barrier identification (Painuly 2001). During the field work, semi-structured interviews are conducted with end consumer of solar home systems where additional insights are also collected through observations. The sites include villages in the Aligarh district which is located in the northern state of Uttar Pradesh in India. Uttar Pradesh is one of the states with the lowest household electrification rate. Multiple companies are approached for performing the field visit but permission is granted only by one company to do the stakeholder interviews. Also, few companies have just started the operations and do not have a well-established customer base and an operations team. Aligarh is chosen as the site for field analysis as it closer to

the national capital of Delhi and relatively easier to travel. Also, it is one of the first regions where the company launched its operations and hence has an active consumer base and an extensive sales and operations team. Therefore, it makes sense to choose this site in terms of accessibility and conducting interviews with a rich customer base. Another reason for only choosing one location for field work is the time and financial constraint on the author's part. It is not practically feasible to visit these locations as they are very far from each other in a large country like India with limited financial resources.

There are various literature sources available which shed light on multiple barriers and strategies for the diffusion of innovative products and services in India and implementation of renewable energy in both developed and developing countries. These literature sources are studied in detail, and a holistic framework is generated out of all these sources and linked to the element of business model canvas. The sources have been retrieved from Google Scholar with the following keywords barriers, renewable, energy, strategies, clean, India, decentralized, photovoltaic, developing and rural electrification. Within ***step 1***, there are two stages of adaptations applied to the Ortt *et al.* framework which is further linked to the business model canvas. In *stage 1*, the adaptation is applied based on the literature sources on barriers and strategies on diffusion of technology and diffusion of renewable energy technologies in India. In *stage 2*, the adaptation is applied based on literature on diffusion of solar home systems in developing countries. The strategies in the adapted framework are linked to nine elements of the business model canvas by understanding the effect of each strategy on these elements. In ***step 2,*** three case studies and three additional expert interviews are conducted. These case studies are based on expert interviews with company executives from three companies which are Simpa Networks, Rural Spark and Philips. The interview questions to company executives are focused on the barriers faced by them, the strategies adopted and their BMC elements. Within step 2, field study is conducted in the rural areas of Aligarh which is located in the northern part of India. This field study is carried out in collaboration with Simpa Networks as an example case to study their operations. This field study has given profound insights into the socio-economic problems of the rural population and the associated barriers to SHS implementation. In addition to this, several interviews with company executives and other stakeholders are conducted to understand the problems encountered at technical, policy, institutional, economic and administrative level.

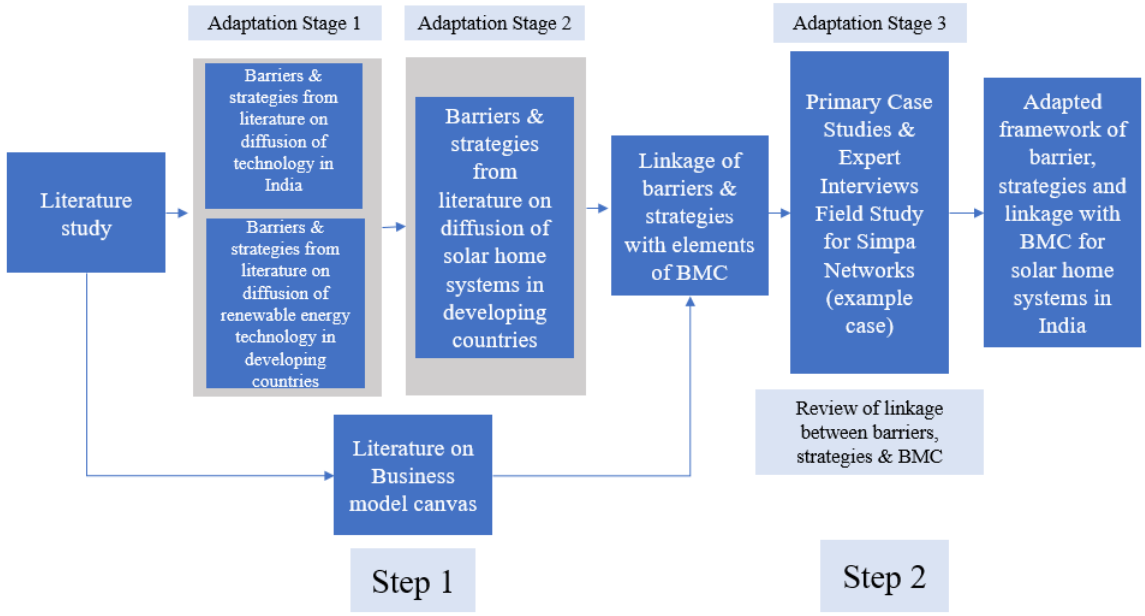

Figure 1-13 Research framework (Author)

Table 1-2 illustrates the relation between the research questions and chapter numbers.

Table 1-2 Research questions and chapter number linkage

Research Questions	Chapter
1. Identification of barriers a) What are the barriers in Ortt's literature for commercializing new high-tech products? b) How can the barriers mentioned in literature for diffusion of renewable energy products in general and solar home systems in particular be combined with the Ortt *et al.* framework?	2,6
2. Identification of strategies a) What are the strategies in Ortt's literature for commercializing new high-tech products? b) How can the strategies mentioned in literature for diffusion of renewable energy products in general and solar home systems in particular be combined with the Ortt *et al.* framework?	2,6
3. What are the elements of business model canvas and how are they defined?	2,6
4. What are the main barriers, strategies and business model canvas elements which are identified from the case studies and expert interviews?	3,6
5. What are the main findings of the field visit in terms of barriers, strategies and linkage with business model elements?	3,6
6. How are the general barriers and strategies in the final adapted Ortt *et al.* framework linked to each other?	2,3,6
7. How can we link the niche strategies from the adapted framework to the elements of the business model canvas?	3,4,5,6

Chapter 6 is the conclusion chapter which in addition to other chapters answers all the research questions one by one.

CHAPTER 2: LITERATURE STUDY

2. Identification of barriers & strategies and linkage with BMC

2.1. Introduction

This chapter focuses on identification of barriers and strategies for the diffusion of high-tech products, renewable energy technology products in particular in developing countries. Further, in this chapter the business model literature would be discussed. Finally, the combined framework of barriers sand strategies would be linked to the business model canvas to understand the effect of each market situation on the elements of BMC and the type of strategy adopted in that case.

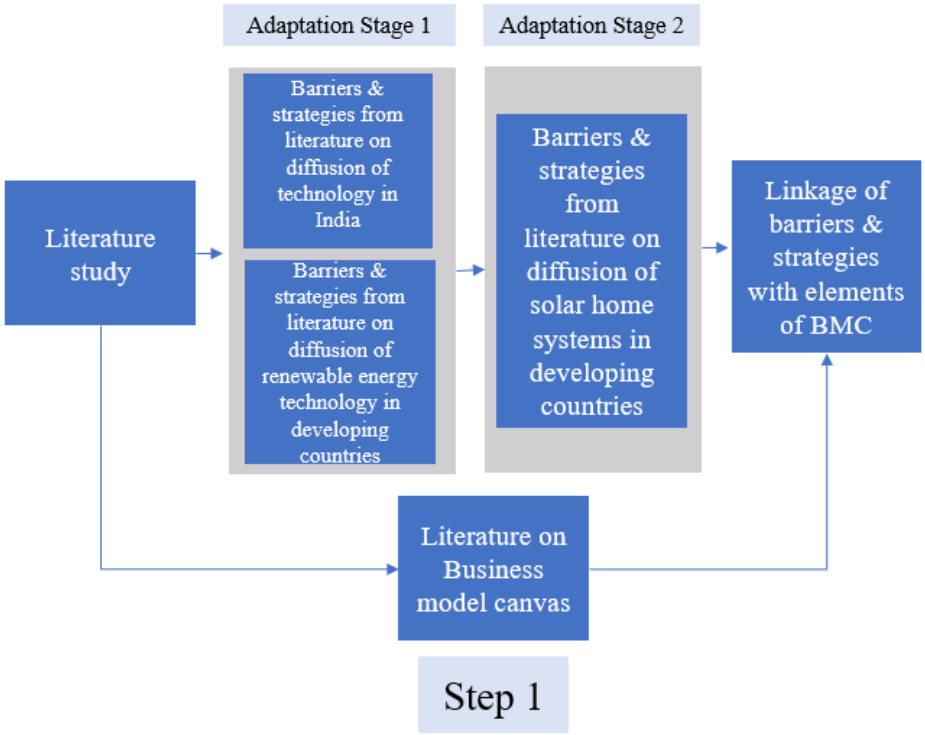

Figure 2-1 Chapter 2 discussed as per methodology chart

2.2. Sources of literature for barrier identification

The framework to identify barriers for diffusion of high-tech products by Ortt *et al.* serves as the basis of our literature study. The Ortt *et al.* framework focuses on the diffusion of high-tech products in only developed nations and not in the developing world. Therefore, to serve this knowledge gap and the context of renewable energy technologies, several literature sources have been considered.

The first section of literature is based on barriers to diffusion of technology and innovations from the Indian perspective. These sources are "Barriers to innovation in Indian small and medium-sized enterprises," "Serving the world's poor: innovation at the base of the economic pyramid" and "The creation and diffusion of innovation in developing countries: A systematic literature review." These sources are studied to reflect on the barriers in general for various technologies, products, and services in the Indian context. This research is imperative as it gives a generic view on the factors which hamper business activities in India.

Next, we study the barriers to renewable energy products in developing countries. These are "Barriers to renewable energy penetration; a framework for analysis" by Painuly discusses a holistic framework to study various set of barriers from a developing nation's perspective discussed in detail further in this chapter. The other literature sources are "Review of barriers to the dissemination of decentralized renewable energy systems" by Yaqoot *et al.*; "Barriers to renewable/sustainable energy technologies adoption: Indian perspective" by Luthra *et al.* and "A model to evaluate the success of Solar Home Systems" by Holtorf *et al.* These literature sources are relevant for this study as they shed light on various barriers to adoption of renewable energy technologies from a developing nation's perspective. The barriers to high-tech innovations are generally common to developing nations as the economic conditions, and societal structure is similar. It is, therefore, pertinent to understand the factors for other developing countries instead of focusing on barriers only from the Indian perspective.

Table 2-1 Literature sources

Literature	Authors	Source & keywords
Ten niche strategies to commercialize new high-tech products	J. Roland Ortt, David J. Langley, Nico Pals (2013)	SCOPUS & Google Scholar (high-tech, products, niche, strategies, barriers, renewable, energy, India, solar home systems, developing countries)
Barriers to innovation in Indian small and medium-sized enterprises	(Pachouri & Sharma 2016)	Google Scholar (barriers, technology, firms, India)
Serving the world's poor: innovation at the base of the economic pyramid	(Anderson & Billou 2007)	Google Scholar (innovation, India, barriers, technology, base of pyramid)
The creation and diffusion of innovation in developing countries: A systematic literature review	(Zanello *et al.* 2016)	
Barriers to renewable energy penetration; a framework for analysis	J.P. Painuly (2000)	
Review of barriers to the dissemination of decentralized renewable energy systems	Mohammed Yaqoot, Parag Diwan, Tara C.Kandpal (2015)	
Barriers to renewable/sustainable energy technologies adoption: Indian perspective	Sunil Luthra, Sanjay Kumar, Dixit Garg, Abid Haleem (2014)	
A model to evaluate the success of Solar Home Systems	Hans Holtorf, Tania Urmee, Martina Calais,Trevor Pryor (2015)	

The above literature sources are combined to form the first level of adaptation to the Ortt *et al.* framework. In the last literature section on barriers, the factors for diffusion of solar home systems in developing countries are considered. These sources are considered to get a more specific framework from the context of the implementation of solar home systems. These sources are combined to form the second level of adaptation to the Ortt *et al.* framework.

2.2.1. Ten niche strategies to commercialize new high-tech products by Ortt *et al.*

Ortt *et al.* provide with a list of twelve actors, factors, and functions responsible for large scale diffusion of high-tech products. Six of these factors have a direct effect on large scale diffusion, and the remaining

six have an indirect effect and these factors are a precondition for the core factors. These core factors which have a direct effect are described below along with the indirect factors.

Table 2-2 Factors affecting large-scale diffusion (Ortt *et al.* 2013)

Indirect (Influencing) factors	Direct (Core) factors
Knowledge of technology	New high-tech product
Knowledge of application	Production system
Natural resources	Complimentary products & services
Socio-cultural aspects	Suppliers (network of organizations)
Macroeconomic aspects	Customers
Accidents or events	Institutional aspects (laws, rules & standards)

These core factors primarily represent the technology, market conditions, and institutional aspects. A specific niche strategy is required when one or more of these factors are hampering the diffusion process. The indirect factors or influencing factors either drive or hinder these core factors. These influencing factors are knowledge of technology and application, the availability of natural resources, socio-cultural and macroeconomic aspects and finally accidents or events that hamper the overall diffusion process. These factors are discussed in detail in *table 2-3* (Ortt *et al.* 2013).

Table 2-3 Factors and their description

Factors	Description
New high-tech product	The high-tech product can be described via three elements (1) the product functionality (2) technology used (3) main components in the system. If any of these elements are missing, large-scale diffusion is not possible. The product also needs to have a good quality and price as compared to competitive products
Production system	Industrial scale production facilities are key to large-scale diffusion
Complimentary products & services	The complimentary products and services which are necessary for production, distribution, adoption and utilization of the product can hamper the large-scale diffusion of the product if any of them are unavailable
Suppliers (network of organizations)	Multiple types of actors are involved in the supply of the product. If these actors, resources, and coordination between them is absent, large-scale diffusion is blocked
Customers	This factor refers to the availability of customer segments, awareness about the product and its applications. If any one of these is not present, diffusion is hampered
Institutional aspects (laws, rules & standards)	The laws and regulations either drive or hamper large-scale diffusion
Knowledge of technology	This factor discusses the knowledge required to produce and develop the product and the technology used
Natural resources & labor	These natural resources and labor are required for the production system, product and its complimentary products and services
Knowledge of application	Lack of knowledge of application of the product can completely hamper the diffusion process
Socio-cultural aspects	They refer to the norms and values of a particular culture which affect the product dissemination
Macroeconomic aspects	The economic situation such as a recession in economy can hamper the diffusion process
Accidents or events	Events like wars, damage to production facilities or any accident during the use of the product can have a severe effect on the diffusion process

2.2.1.1. Insights from previous thesis projects

There have been earlier projects to adapt the Ortt *et al.* framework for various technologies in developing countries. These studies were undertaken by master students at the Delft University of Technology, The Netherlands as their graduation projects presented below:

Name	Track	Study	Technology/Products discussed
Nicole J. van den Berg	MSc Industrial Ecology, 2017	Niche strategy selection in developing countries: a case study on RE-desalination	Technologies in general
Lusi Pratiwi	MSc Management of Technology, 2016	Barriers and strategies for transition to electric vehicles in BRICS countries: Case study of South Africa, India & Brazil	Electric vehicles
Boma Harahap	MSc Management of Technology, 2014	Barriers and niche strategies for scaling-up technology firms at the base of pyramid	Biomass cook stoves, drinking water purifier, solar lantern

Key insights from Nicole J. van den Berg (Berg 2017)

The framework presented by Nicole is a generic framework for barriers and niche strategy selection for developing countries which increases the scope of its usability. A key insight from Nicole's work is the discussion on adaptation levels in Ortt's framework (discussed in next section). This framework provides the type of adaptations which are possible in Ortt's framework. Also, a clear distinction between core and influencing factors have been made in this work. The developing countries framework by Nicole resulted in 20 factors (10 core and 10 influencing) and 12 niche strategies (2 entirely new). The most important core factors are customers, affordability and institutional aspects whereas the most important influencing factors are labour, socio-cultural aspects, macro-economic aspects and physical/information access and infrastructure. The framework for RE-desalination generated 25 factors (14 core and 11 influencing factors) and 14 niche strategies (2 entirely new). Here the most important core factors are networks of organizations, public awareness, lack of training, ownership/responsibility distribution, bureaucratic structures, government priorities and support, water production and property rights. The influencing factors which are focused are technology developers' knowledge on niche markets, suitable technology selection and sustainability understanding. The niche strategies which were stressed upon are demo, experiment and develop, exploration of multiple markets and local niche strategies.

Key insights from Lusi Pratiwi (Pratiwi 2016)

The framework in this work is based on different electric vehicle manufacturers in BRICS countries. The relationship between core and influencing factors is not defined clearly as in the original framework by Ortt *et al.* However, these factors were ranked on the basis of importance level in various interviews. The final list of barriers consists of 13 barriers categorized as Production system, Complementary technologies, Network, Demand, Institutional, Technological, Natural resources and labour, Social, cultural, behavioural, and psychological, Macro-economic, Accident or events; Infrastructure, Financial, and Undesirable societal and environmental effect. Lusi identified 15 strategies which are Demo, experiment, and develop niche Strategy, Top niche market strategy, Pilot project strategy, Lobbying strategy, Redesign niche strategy, Dedicated system or stand-alone niche strategy, Hybridization or adaptor niche strategy, Knowledge Development, Geographic niche strategy, Market research; Explore multiple markets niche strategy, Financial aid strategy, Establishment of standard strategy, Network creation strategy, Development of infrastructure strategy.

Key insights from Boma Harahap (Harahap 2014)

Boma's work describes the barriers and niche strategies for technology firms at the base of the pyramid making it a very specific framework. One of the important insight from Boma's work is the formation of the combined framework from various literature sources. The combined framework is very clear in itself and gives a clear idea on a comparison between different kinds of literature. However, there is no distinction between core and influencing factors in Boma's work. The barriers in this work are rather classified under company, market and consumers. The final list of barriers consisted of 21 barriers and out of these, nine barriers are categorized as essential at BoP which are Financial Capital, Affordability, Consumer's Awareness, Institutional aspects, Knowledge of Application, Production system, Consumer's Demand, Natural Resources Labor & Employee and Infrastructure. Fifteen strategies have been identified and out of which nine are categorized as essential. These are partner network strategy, access to finance, education approach, demo experiment and develop, explore multiple markets, geographic approach, technology complementary strategy and upper-income BoP market segment approach.

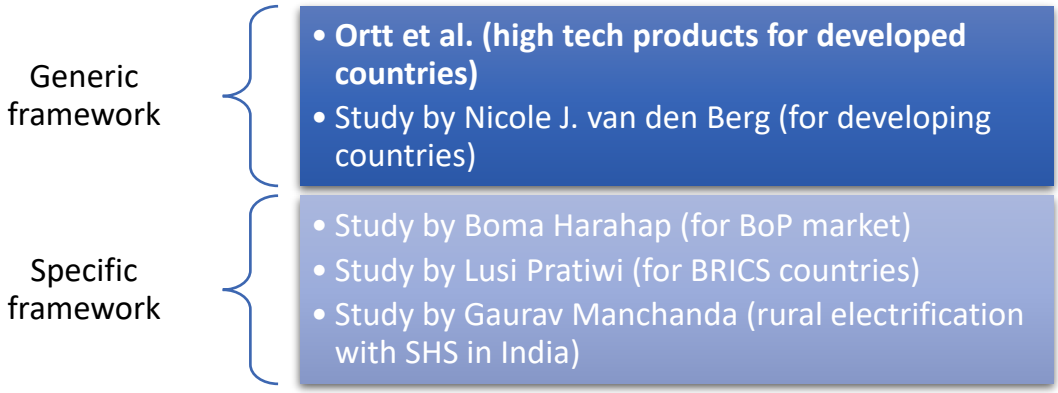

Figure 2-2 Categorization of generic and specific frameworks

2.2.1.2. Adaptation levels

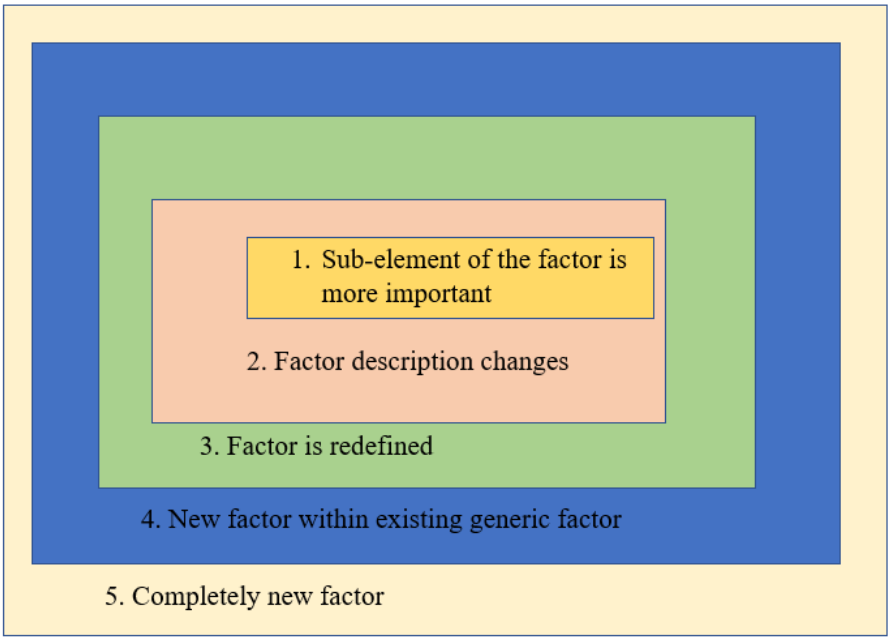

Figure 2-3 Adaptation framework (adapted from Nicole J. van den Berg, 2017)

The adaptation of the Ortt's framework can be categorized into five levels as described in *figure 2-3*. In the first level, minimum adaptation is required where the sub-element of the factor is more important. In the second level, the description of the factor changes as compared to the original framework. In the third level, the factor is renamed and redefined according to the literature under consideration. The fourth level argues for a new factor within the existing generic factor and the fifth level gives an entirely new factor which is not present in the original framework.

Barriers from literature on diffusion of technology, products and services in India

2.2.2. Barriers to innovation in Indian small and medium-sized enterprises

India is ranked 130th in the World Bank list of ease of doing business for 2015 which gives an indication that numerous barriers exist in the country for doing businesses. This paper focuses on the current state of innovation in SME's in India and also discusses its barriers and enablers. In this section, the key barriers to innovation that impedes the growth of SME's in India are discussed. These barriers are categorized into people, financial, information, government policy, infrastructure and market constraints (Pachouri & Sharma 2016).

Table 2-4 List of barriers (Pachouri & Sharma 2016)

Barrier	Explanation
People & skills	More than 85% of the SME's see lack of skilled personnel which impedes innovation and the overall efficiency is hampered due to lack of right internal management
Financial	Lack of finance is a major barrier as the cost of innovation is typically high and limited access to these financial resources
Information	Lack of access to information on technology and market
Government policy	Nearly 70% of the innovative SME's see government policy and meeting regulatory requirements as one of major challenges in doing business
Infrastructure	Limited access to laboratories and research institutes has been cites as barrier by 35% of the innovative SME's
Market constraints	Uncertain demand for innovative products and services, protectionist nature of the market & Intellectual property rights issues

2.2.3. Serving the world's poor: innovation at the base of the economic pyramid

India has about 171 million low-income households, and the reach by multinational companies to these consumers has been very uneven. This is due to a number of barriers which are corruption, poor infrastructure, non-existent distribution channels, illiteracy, lack of robust and enforceable legal frameworks, religious or racial conflict, and sometimes even war or violent insurgencies. Anderson & Billou came with a 4A approach for the organization's success to reach out to these consumers and diffuse their products in the market. These 4A's are availability, affordability, acceptability & awareness.

Figure 2-4 4As (Anderson & Billou 2007)

Table 2-5 4A's and corresponding barriers (Anderson & Billou 2007)

4A's	Examples from Indian perspective	Barriers discussed
Availability	HUL, India's giant in consumer goods market, has developed and grown its distribution network which serves in the remotest of the areas.	Non-existent or fragmented distribution channels, poor road infrastructure
Affordability	Two-thirds of Indian villagers are in the bottom income band making them price sensitive	Affordability, low income of consumers,
Acceptability	The perception of Indian women in rural areas is that shampoos are too harsh for their hair, so they preferusing a single soap for body and hair	Acceptability due to socio-cultural issues, perception of consumers
Awareness	In India, only 41% of the poor rural households have access to TV, and the rest of the households are alien to the conventional media advertising	Building awareness

2.2.4. The creation and diffusion of innovation in developing countries

In this literature review, Zanello *et al.* collected evidence on barriers on innovation creation and diffusion to and within developing countries. The findings from this literature review shed light on a number of barriers which are categorized into external and internal factors as per *figure 2-5*. The external factor contributes to the factors which are affecting from outside the organizations whereas the internal factors are affecting from within the organization.

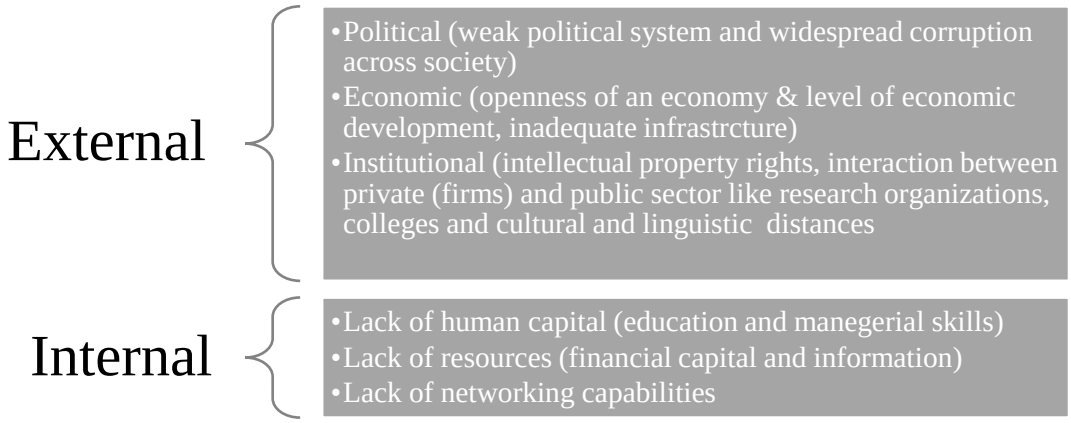

Figure 2-5 List of internal and external factors (Zanello et al. 2016)

Empirical evidence of barriers from the Indian context

- An analysis of 1600 Indian firms from the World Bank Enterprise Survey revealed that ***corruption in the form of bribes*** weakened the possibility of the introduction of new products.
- An analysis of 291 firms in manufacturing revealed that a new market entrant is limited by government policies. Lack of competition discouraged firms to invest in R&D.
- The collaboration between Indian national chemical laboratories and local firms remained very poor. Also, lack of complimentary activities and insufficient technological progress at the labs deteriorated the collaboration relationship.
- A study revealed that the lack of right technology was a barrier for the manufacturing sector in India.

Barriers from literature on diffusion of renewable energy technology in developing countries

2.2.5. Barriers to renewable energy penetration; a framework for analysis

Painuly in his paper identified a holistic framework to list down the barriers faced by RET's. He emphasized on literature survey, site visits and interaction with stakeholders as one of the key approaches for barrier identification. Painuly also cites several strategies to overcome these barriers effectively. His framework is based on a project based in three African countries on RETs – Opportunities and Barriers. The barriers and sub-barriers are listed below in *table 2-6* (Painuly 2001).

Table 2-6 Barriers to renewable energy penetration (Painuly 2001)

Barrier category	Sub-barrier	Explanation
Market failure/imperfection	Highly controlled energy sector	This may lead to lack of investments in RETs; private sector entry is restricted thus leading to monopoly of government energy sector
	Lack of information & awareness	Lack of awareness of technology, cost, benefits, agencies to disseminate information and lack of knowledge for resource assessment. It increases uncertainty, and hence costs
	Restricted access to technology	Technology not available or available at high cost

	Lack of competition	Product cost increases as regulation does not allow entry of private players
	High transaction costs	
	Missing market infrastructure	Under-developed supply channels, poor logistics, inconvenient product location
	High investment requirements	This acts as an entry barrier for entrepreneurs
Market distortions	Favor (such as subsidies) to conventional energy	This affects competitiveness of renewable energy adversely as conventional energy is subsidized and low taxes as compared to RET's
	Taxes on RETs	Cost of energy from RETs increases (direct/indirect taxes and import duties)
	Non-consideration of externalities	Cost of conventional energy is less than what it should be (negative impacts such as pollution, damage not valued)
	Trade barriers	Cost of RETs may go up, for example, due to high taxes on RET imports
Economic & Financial	Economically not viable	High cost of product, resources, and implementation
	High discount rates	Higher discount rates for producers/manufacturers/consumers. Also, the risk perception is high
	High payback period	Project becomes unviable as the rate of return is low
	Market size small	Untapped RET market, existing market barriers, difficult to access international market, less potential
	High cost of capital	High interest rates, unfavorable government policies, inflation rate
	Lack of access to capital	Distorted capital market, poor policies, and regulations
	Lack of access to credit to consumers	Credit market not fully developed, recovery problems, poor credit worthiness
	High up-front capital costs for investors	Capital costs may also go up due to increased risk perception. Lack of financing mechanism
	Lack of financial institutions to support RETs, lack of instruments	Under-developed capital market, lack of regulations, restricted entry to capital market
Institutional	Lack of institutions/mechanisms to disseminate information	Lack of regulating bodies or institutions, lack of capacity in current organizations
	Lack of a legal/regulatory framework	Lack of regulations or unfavorable rules and regulations

	Problems in realizing financial incentives	Complicated procedure, red tape, corruption
	Unstable macroeconomic environment	High inflation, uncertain economic growth, exchange rates, price fluctuations
	Lack of involvement of stakeholders in decision-making	Consultation from stakeholder is missing
	Clash of interests	Competition with conventional energy players and may lead to powerful lobbies against RETs
	Lack of R&D culture	R&D facility and capacity missing
	Lack of private sector participation	Restrictive regulations
	Lack of professional institutions	Absence of associations, consumer bodies, lack of feedback to policy makers
Technical	Lack of standard and codes and certification	Lack of institutions and capacity to fix standards
	Lack of skilled personnel/training facilities	Lack of training facilities and experts
	Lack of O&M facilities	Lack of capacity
	Lack of entrepreneurs	Low profitability and restrictive regulations
	System constraints	Integration with grid problems and lack of skill
	Product not reliable	Bad quality, work ethics, lack of quality control
Social, Cultural & behavioral	Lack of consumer acceptance of the product	Culturally not accepted, lack of information, resistance to change
	Lack of social acceptance for some RETs	Alien technology, no local participation, preference for traditional energy
Other	Uncertain governmental policies	Uncertain and unsupportive policies, red tape, inadequately equipped government agencies
	Environmental	Local pollution, ecological aspects, competition for resources (biomass)
	High-risk perception for RETs	Uncertain technology and benefits, high investment risk

	Lack of infrastructure	RETs such as in wind energy may need strong infrastructure development such as roads, grid connectivity, and logistics

2.2.6. Review of barriers to the dissemination of decentralized renewable energy systems

Barriers to the dissemination of renewable energy technologies negatively affect the adoption and diffusion process. In this paper, the barriers are generally classified as technical, economic, institutional, socio-cultural and environmental. These barriers are further categorized into various sub-barriers as described in *table 2-7*. These barriers are identified from vast literature sources across different regions of the world. In the below table, along with an explanation, a relevant example is cited for better understanding. The examples mentioned below are particularly taken from a developing country's perspective which would support our framework and research objective.

Table 2-7 Barriers to the dissemination of DRES's (Yaqoot *et al.* 2016)

Barrier category	Sub-barrier	Explanation	Example
Technical	Resource Availability	Intermittency or inadequacy of resource availability	Lack of resource availability acts as a barrier for family type biogas plant, box type solar cooker, domestic solar water heater, solar PV lantern in India
	Technology - design, installation, and performance	The inappropriateness of technology or poor design is a significant technical barrier.	Failures due to complex design, lack of standardization and poor reliability are reported to be significant barriers for wind energy in India
	Skill requirement for design and development, manufacturing, installation, operation & maintenance	Negative impact on the diffusion process due to lack of skilled workers	Lack of trained technicians is hindering wind turbine installations in Turkey
Economic	Cost	DRES suffer from high upfront cost	Availability of zero cost options for cooking discourages the use biomass or solar cook stoves due to its high initial cost in rural areas of India
	Market structure	Existing market structure and its policies favor conventional energy through subsidies and other incentives. Lack of competition, trade barriers, and inadequate information	Distortions (policies favoring conventional energy technologies) in energy market is reported as a barrier to diffusion of DRES's in India
	Energy pricing	High cost of electricity from DRES's for rural	In the state of Punjab, India solar PV pumps are uncompetitive compared to

		electrification is a major barrier to the diffusion process	the pumps which operate on subsidized electricity and diesel
	Incentives	Inadequate incentives to promote the adoption of DRESs	Conventional power generation technologies have the edge over PV technology due to favorable policies for the former in developing countries
	Purchasing power & spending priorities	Poor purchasing power (non-affordability) of the customers is a significant barrier	In rural Bangladesh, the use of solar home systems for un-electrified areas is being hampered due to poverty and poor purchasing capability
	Financial issues	Lack of access to credit availability is cited to be a major hindrance	Lack or limited access to financial instruments and high payback period is hindrance to diffusion of DRES's in India
	Awareness & risk perception	Awareness of the technology and product among all the stakeholders is necessary. The risk perception is high for renewable energy technologies	In Kenya, lack of information for family type biogas plants is affecting its adoption among local farmers The communities in developing countries have a general opinion that renewable energy options are generally expensive as compared to the conventional ones
Institutional	Policy & regulatory	Lack of consistent policies and regulations is a major hindrance	
	Institutional Infrastructure (institutions for research, design and after-sales services)	Barriers related to lack of institutional, financial and technical structures, service infrastructure to promote distribution, sales, services	Underdeveloped extension services for spare parts supply and maintenance services is a major barrier to DRES's in rural areas
	Administrative	Lack of coordination between various stakeholders; poor monitoring and evaluation; bureaucratic administrative procedures	Lack of a good coordination between ministries and agencies has been reported as major administrative barrier in Bangladesh
Socio-cultural	Societal structure, Norms & value system	Un-satisfied perceived needs and non-integration of technology with the current societal norms and structure	Improved biomass cookstoves were not accepted as the local people believed that by burning open fire, the family spirit resided in it rather than in the former one.

	Awareness & risk perception	Lack of information and awareness creates a perception for DRES's to be inferior technologies	Inadequate demonstrations of solar energy devices is a significant barrier in Pakistan
	Behavioral or lifestyle issues	Preference for traditional energy sources and resistance to change to new technologies is a significant barrier	
Environmental	Resources (land and water), pollution, aesthetics	Competition for natural resources	non-availability of water has been reported as one of the significant barriers to the utilization of biogas engine in India

2.2.7. Barriers to renewable/sustainable energy technologies adoption: Indian perspective

Luthra *et al.* studied various barriers listed in literature such as financial, market, awareness, technical, ecological, cultural and political. These barriers are examined for the adoption of sustainable energy technologies from the Indian context. Their work also includes literature for other developing and developed nations with a similar energy scenario as of India. These barriers are discussed in detail below (Luthra *et al.* 2015).

Table 2-8 Barriers to renewable energy technologies (Luthra *et al.* 2015)

Barrier category	Sub-barrier	Explanation
Economic & Financial	High initial capital cost	Imported technology from technologically advanced countries are highly efficient but more expensive than the local technology
	Lack of financing mechanism	Lack of government incentive schemes and financing mechanisms for the promotion of renewable energy technologies is a significant barrier
	Transmission & distribution losses	RET's may depend upon geographic conditions, and the point of consumption may be far away from the source leading to T&D losses
	Lack of Proven reliability (redefined from inefficient technology)	
	Lack of subsidies	Lack of financial incentives such as subsidies, rebates, tax exemption, low-interest loans, etc
Market	Lack of consumer awareness of technology	Poor access to information about RET's and their costs and benefits leads to uncertainty about these products
	Lack of sufficient market base	
	Unable to meet electricity power demand alone	Only one RET cannot alone satisfy the growing needs. Integration of various RET's is required

	Lack of paying capacity	Limited capacity, low incomes, and unwillingness to pay for these RET's have created a significant barrier to their diffusion
Awareness & Information	Need for backup or storage device	Due to intermittent nature of solar power, for continuous supply back-up is required where disposal of these storage devices is a major environment issue
	Unavailability of solar radiation data	To establish solar power projects, solar irradiation data is required, and in the absence of this, it acts as a barrier
	Lack of IT enablement	Information flow and communication is a major roadblock for technology transfer
Technical	Lack of awareness of technology	Lack of information and awareness of technology among the rural populace is an important barrier.
	Less efficiency	Perceived as usage with discomfort
	Technology complexity	Complex technological principles
	Lack of research & development work	Lack of R&D and investment in R&D is one of the critical barriers
	Lack of trained people & training institutes	Technically trained people with sound management skills is required for faster adoption of RET's
	Lack of local infrastructure	The local infrastructure refers to the physical facilities of transmission and distribution networks and necessary equipment's and services for power companies
	Lack of national infrastructure	This refers to the problems based on infrastructure availability such as roads, grid connectivity, communications and other logistics.
Ecological & Geographical	Scarcity of natural & renewable resources	Unprecedented natural resource consumption and environment impact
	Geographic conditions	Intermittent and uneven geographic distribution of solar resources
	Ecological issues	Impact due to land use and habitat loss and use of hazardous materials during manufacturing
Cultural & Behavioral	Lack of experience	No experience and information on the consumer part to use the product
	Rehabilitation controversies	Mostly relevant to hydroelectric projects in the mountain region
	Faith & Beliefs	Leads to general resistance to change
Political & Government Issues	Lack of political commitment	Political instability, corruption, government intervention in domestic market are major barriers
	Lack of adequate government policies	No comprehensive policy statements for India
	Lack of public interest litigations	PIL lacks in India as certain labeling programs (energy usage and efficiency claims) are not mandatory

2.2.8. A model to evaluate the success of Solar Home Systems

Holtorf *et al.* in their study mention five major barrier categories for the implementation of Solar Home Systems. These barriers are categorized as implementation, financial, technical, policy and social. *Table 2-9* lists 21 sub-barriers responsible for dampened growth in SHS market. These factors determine the critical success factors which are used in the further part of their study (Holtorf *et al.* 2015).

Table 2-9 Barriers to Solar Home Systems (Holtorf *et al.* 2015)

Barrier category	Sub-barrier
Implementation	Lack of technical knowledge
	Lack of institutional capacity
	Lack of private sector involvement
	Lack of involvement of local stakeholders
	Limited markets
Financial	Lack of capital
	High capital costs / high-interest rates
	Lack of program financing
	Lack of user credit
	No income generation
Technical	Poor maintenance
	Poor installations
	Limited product availability
	Insufficient logistic infrastructure
	Technical insufficiency (capacity, efficiency)
Policy	Lack of policy & legal framework
	Improper use of subsidies
	Donor dependency
	Donor driven
Social	Misperceptions on the technology
	No link to existing social structures & values

2.2.6. Adaptation of Ortt *et al.* framework (Stage 1)

In *table 2-10*, the various barrier elements from different literature sources are mapped to the factors in Ortt *et al.* framework where their definition in the combined list is either adapted, or a new factor is added. The adapted framework consists of twenty factors where eight new factors have been added. Also, the definition of the existing factors is enriched from the renewable energy technology perspective particularly for a developing country. New high-tech product refers to the availability, reliability and economic viability of the product, complementary products and services refer to the poor market infrastructure which is the unavailability of the supply channels and poor logistics for product distribution. Another important factor cited is the consumer awareness and affordability which deals with the degree of awareness and purchasing power of the consumers. Lack of institutional mechanisms, regulations and lack of administrative expertise are covered under the barrier – Institutional aspects. Financial barriers are listed as the lack of financing mechanisms for consumers and high investment for companies involved. Lack of participation of local stakeholders is also cited as a major barrier. The entrepreneurial activity is also missing which means the market is yet to open up completely. The barrier elements missing in literature sources are filled with dark blue in color and the new adapted framework is filled with green color.

Table 2-10 Adaptation of Ortt et al framework (core & influencing factors) (Gaurav Manchanda, 2017)

S.No.	Ortt *et al.*	Painuly	Yaqoot *et al.*	Luthra	Holtorf	Adapted Ortt *et al.*
1.	New high-tech product	Economically not viable Product unreliable	Cost	High initial capital cost	Limited product availability	New high-tech product
2.	Production system	Lack of O&M facilities				Production system
3.	Complimentary products & services	Missing market infrastructure	Institutional infrastructure – after sales services			Complimentary products & services
4.		Lack of infrastructure		Lack of local infrastructure Lack of national infrastructure	Insufficient logistic infrastructure	Infrastructure
5.	Suppliers (network of organizations)					Suppliers (network of organizations)
6.	Customers	Market size small Lack of consumer acceptance			Limited markets	Customers
7.		High-risk perception for RETs, Lack of awareness and information	Awareness & risk perception,	Lack of consumer awareness to technology, Lack of IT enablement Lack of Proven reliability	Misperceptions on the technology	Consumer awareness & risk perception
8.			Purchasing power & spending priorities	Lack of paying capacity	No income generation	Affordability
9.	Institutional aspects (laws, rules & standards)	Highly controlled energy sector Lack of competition High transaction costs Favorable treatment to conventional energy Taxes on RET's Non-consideration of externalities Trade barriers Lack of institutions and mechanisms Lack of a legal/regulatory framework Problems in realizing	Market structure Incentives Policy & regulatory Institutional infrastructure (institutions for research, design and after-sales services) Administrative	Lack of subsidies Lack of adequate government policies Lack of public interest litigations Lack of research & development work	Lack of institutional capacity Lack of private sector involvement Lack of policy & legal framework Improper use of subsidies Donor dependency Donor driven	Institutional aspects (laws, rules & standards)

		financial incentives Lack of standards, codes, and certification Uncertain government policies Lack of R&D culture Clash of interests Lack of private sector participation Lack of professional institutions				
10.	Knowledge of technology	System constraints Restricted access to technology	Technology - design, installation & performance	Unavailability of solar radiation data Technology complexity Transmission & distribution losses	Lack of technical knowledge Poor maintenance Poor installations Technical insufficiency (capacity, efficiency)	Knowledge of technology
11.	Natural resources & labor	Lack of skilled personnel	Resource availability Skill requirement for design and development, manufacturing, installation, operation & maintenance	Lack of trained people & training institutes Scarcity of natural & renewable resources		Natural resources & labor
12.	Knowledge of application					Knowledge of application
13.	Socio-cultural aspects	Lack of social acceptance + Lack of involvement of stakeholders in decision-making	Societal structure Norms & value system Behavioral or lifestyle issues	Lack of experience Faith & Beliefs	No link to existing social structures & values + Lack of involvement of local stakeholders	Socio-cultural aspects
14.	Macro-economic aspects	Unstable macroeconomic environment				Macroeconomic aspects
15.	Accidents or events			Rehabilitation controversies		Accidents or events
16.		High investment requirements for entrepreneurs High discount rates for producers and consumers High payback period High cost of capital Lack/inadequate access to capital	Energy pricing Financial issues	Lack of financing mechanism	Lack of capital High capital costs / high-interest rates Lack of program financing Lack of user credit	Financial and high investment

		Lack of access to credit to consumers High upfront capital costs for investors Lack of financial institutions and mechanisms				
17.				Lack of political commitment		Political
18.		Environmental	Environmental	Ecological issues		Environmental

2.2.6.1. Categorization into core and influencing factors

Table 2-11 indicates the adapted list of direct (core) and indirect (influencing) factors. The factors marked in color orange are completely new factors added to the Ortt *et al.* framework. Also, the description of some of the factors is either changed or added are also colored in orange. Within the influencing factors, knowledge of technology, knowledge of application, macroeconomic aspects and accidents or events remain the same as in the original framework. The socio-cultural aspects are enriched with the inclusion of lack of local stakeholders in decision making. The natural resources description is enhanced by the inclusion of "skilled personnel" which was earlier missing in the original framework. Completely new factors are added to the list of influencing factors which are ***Affordability, Infrastructure, Environmental and Political.*** Within the core factors, in the new high-tech product, the sub-element high cost is the most relevant. In the production system, in addition to the old definition, the lack of O&M facilities is also added. Under complimentary products and services, distribution and use of products is highly important which comes in the form of underdeveloped supply channels and lack of after sales service. The definition of "supplier" is very generic and unclear in the original framework, hence it adapted to "manufacturers and vendors of raw materials and spare parts". The customers description is same as in the original framework. In the institutional aspects description, the lack of adequate government policies and institutional capacity is added to enrich the original description. ***Consumer awareness & risk perception and Financial*** factors are added to the list of core factors which are completely new in nature.

Consumer awareness & risk perception are classified as direct factors. Consumer awareness and risk perception influence the adoption of solar home systems in developing countries as there is a lack of knowledge among customers and they perceive it to be a risky investment. Lack of awareness and education among customers directly affect the diffusion process and hence considered to be a core factor. Lack of access to finance is a primary barrier which is due to the absence of financing mechanisms and financial instruments for both consumers and companies. This barrier occurs due to lack of knowledge of technology and application among various organizations. A consumer with no capital cannot buy the product and a company with no capital cannot perform its operations, hence affects the diffusion process directly.

The new indirect factors are classified as affordability, infrastructural, environmental and political as they have an influencing effect on the core factors and do not directly impact the diffusion process. Affordability is defined by the economic situation of the region which directly impacts the availability of customers and hence has an influencing effect on them. Lack of basic infrastructure as roads and communication would affect the production system, transportation of raw material & goods and other supply chain services. Therefore, this factor has an impact on complimentary products & service and the production system. The socio-cultural aspects might hamper the new high-tech product and affect the availability of customers and therefore categorized under influencing factors. The political factors such as lack of political commitment and political instability are major barriers towards adoption of

renewable energy technologies. This has an influencing effect on institutional aspects which is a core factor. Environmental factors such as impact on the natural resources and use of hazardous materials in manufacturing directly affects the production system and the availability of new high-tech product. Therefore, it is considered to be an influencing factor.

Table 2-11 Adaptation (Stage 1) Influencing and core factors

Indirect (Influencing) factors	Direct (Core) factors
Knowledge of technology *Same as in original*	***New high-tech product (cost)*** *High capital cost*
Knowledge of application *Same as in original*	***Production system*** *Original + Lack of O&M facilities*
Natural resources *Original + Lack of skilled personnel*	***Complimentary products & services*** *Underdeveloped supply channels, lack of after sales services*
Socio-cultural aspects *Same as in original + Lack of local stakeholders in decision making*	***Suppliers (manufacturers and vendors of raw material, spare parts)***
Macroeconomic aspects *Same as in original*	***Customers*** *Same as in original*
Accidents or events *Same as in original*	***Institutional aspects (laws, rules & standards)*** *Original + Lack of adequate government policies, lack of institutional capacity, lack of information to companies on market scenario*
Affordability *Lack of paying capacity, no income generation*	***Consumer awareness & risk perception*** *Lack of consumer awareness, high risk perceptions, misperceptions*
Infrastructure *Lack of infrastructure such as roads*	***Financial*** *Lack of financing mechanisms for consumers and lack of access to capital for companies, high cost of innovation, high investments*
Environmental *Local pollution, ecological issues, use of hazardous materials during production*	
Political *Lack of political commitment, widespread corruption*	

2.3. Barriers to dissemination of solar home systems in developing countries

The next step in our methodology is to adapt the combined list of barriers through a wide literature base for diffusion of solar home systems in developing countries. In the database of Scopus, literature sources were searched with keywords: developing, countries, solar, home, systems and barriers. 8 literature sources with different barrier elements were identified and used for further adaptation of the Ortt *et al.* framework. In *table 2-12*, the first column refers to the eighteen identified barriers from *table 2-11*, and in addition to this, one more barrier is identified during the adpatation process which is business knowledge. Column 2 gives the description of the barrier as mentioned in the literature. Column 3 indicates the source of the barrier and column 4 gives the degree of importance of that barrier which is the number of sub-barriers mentioned in the literature.

Table 2-12 List of barriers from literature on barriers to SHS in developing countries

Adapted Ortt *et al.*	Description from the paper	Source
New high-tech product	High cost of solar systems, initial capital investment and operation and maintenance	(Kweka *et al.* 2011)
	High initial investment in these systems to a rural household	(Purohit 2009)
	high initial investment and still higher costs of these systems to the end users as compared to their conventional counterparts,	(Purohit & Michaelowa 2008)
	emphasis is more on technology development rather than product development to effectively meet the user's needs	(Purohit & Michaelowa 2008)
	High initial capital cost	(Pode 2013)
	High first cost and affordability	(Martinot *et al.* 2001)
	High capital cost, initial purchase price	(Cabraal *et al.* 1996)
	High cost	(Barua *et al.* 2001)
Production system	Lack of excellent market support infrastructure	(Purohit & Michaelowa 2008)
Complimentary products & services	Lack of established dealer network and secure after sales service	(Kweka *et al.* 2011)
	Lack of technical support for installation and maintenance	(Purohit 2009)
	lack of technical support for installation and maintenance	(Purohit & Michaelowa 2008)
	access to these products is currently poor and rural reach has not been impressive so far	(Purohit & Michaelowa 2008)
	PV module availability	(Urmee & Harries 2009)
	Spare parts availability	(Urmee & Harries 2009)
	Lack of proper maintenance	(Barua *et al.* 2001)
Infrastructure	Lack of excellent market support infrastructure	(Purohit & Michaelowa 2008)
Suppliers (network of organizations)	Lack of excellent market support infrastructure	(Purohit & Michaelowa 2008)
Customers (including their needs)	Lack of established market	(Martinot *et al.* 2001)
	The market for SPV lanterns and solar home lighting systems is currently supply driven as user's needs have not been fully addressed by the suppliers	(Purohit & Michaelowa 2008)
Consumer awareness & risk perception	Limited awareness of and experience with PV technology	(Kweka *et al.* 2011)
	awareness level of the benefits of SPV lanterns and solar home lighting systems is low	(Purohit & Michaelowa 2008)
	fear of users not to receive maintenance in case of breakdown	(Purohit & Michaelowa 2008)
	unfamiliarity of the SPV technology	(Purohit & Michaelowa 2008)

	Lack of information about products, costs, and benefits	(Martinot *et al.* 2001)
Affordability	Low purchasing power of rural people	(Kweka *et al.* 2011)
	Financial affordability	(Purohit & Michaelowa 2008)
	High first cost and affordability	(Martinot *et al.* 2001)
	Credit Risk	(Martinot *et al.* 2001)
Institutional aspects (laws, rules & standards)	Inadequate policy implementation	(Kweka *et al.* 2011)
	Stiff competetion from subsidized conventional energy	(Purohit 2009)
	Stiff competetion from subsidized conventional energy	(Purohit & Michaelowa 2008)
	Lack of government policy	(Urmee & Harries 2009)
	Government subsidy	(Urmee & Harries 2009)
	Unstable government policy	(Urmee & Harries 2009)
	Unwillingness of utilities to provide off grid electricity services	(Martinot *et al.* 2001)
	Lack of experience regulating rural energy concessions	(Martinot *et al.* 2001)
	High import duties	(Martinot *et al.* 2001)
	Unrealistic rural electrification policies	(Martinot *et al.* 2001)
	Lack of information about product quality and performance	(Martinot *et al.* 2001)
	Market distortions	(Cabraal *et al.* 1996)
Knowledge of technology	Limited technical knowledge of sizing, installation, operation and maintenance.	(Kweka *et al.* 2011)
	Lack of technical knowledge	(Urmee & Harries 2009)
	Poor system quality	(Martinot *et al.* 2001)
	Uncertain technological track record	(Martinot *et al.* 2001)
	Unreliable technical performance	(Barua *et al.* 2001)
Natural resources & labor	intermittent nature of the solar energy resource	(Purohit & Michaelowa 2008)
	Lack of trained personnel to take care of the system	(Barua *et al.* 2001)
Knowledge of application		
Socio-cultural aspects	Poverty	(Urmee & Harries 2009)
	Low education level	(Urmee & Harries 2009)
	Credit risk & collection concerns	(Martinot *et al.* 2001)
	The top down approach excludes the poor people to make their own decisions	(Kweka *et al.* 2011)
	Lack of involvement of local communities in program design	(Urmee & Harries 2009)
Macroeconomic aspects	Macroeconomic crisis in Indonesia	(Martinot *et al.* 2001)
Accidents or events		
Financial and high investment	High cost of solar systems, initial capital investment and operation and maintenance	(Kweka *et al.* 2011)

	Difficult access to finance for end users	(Kweka *et al.* 2011)
	Lack of affordable credit at the end user level	(Purohit 2009)
	poor access to adequate financial resources including working capital and lack of innovative financing mechanism including micro and retail financing	(Purohit & Michaelowa 2008)
	No soft credit available	(Urmee & Harries 2009)
	High transaction	(Urmee & Harries 2009)
	Lack of financing	(Urmee & Harries 2009)
	Lack of sufficient fund	(Urmee & Harries 2009)
	Non-availability of facile finance to rural population at the grass-root level	(Pode 2013)
	lack of financing options	(Pode 2013)
	Lack of business financing and skills	(Martinot *et al.* 2001)
	High transaction costs	(Martinot *et al.* 2001)
	Lack of consumer financing	(Martinot *et al.* 2001)
	Lack of access to credit	(Cabraal *et al.* 1996)
	High transaction costs	(Cabraal *et al.* 1996)
Political	Unrealistic political promises of grid extension	(Martinot *et al.* 2001)
Environmental		
Business Knowledge	Inadequate business knowledge and capacity for distribution	(Kweka *et al.* 2011)
	Lack of strong marketing network	(Purohit & Michaelowa 2008)
	Improper management (organization)	(Urmee & Harries 2009)
	Lack of successful business models	(Martinot *et al.* 2001)

2.3.1. Analysis

The barrier "new high-tech product" mostly refers to the high upfront cost of the product as the main obstacle to the diffusion process. The barrier "complementary products and services" was discussed in terms of the dealer network for distribution of products, availability of spare parts and technical support for installation and maintenance services. Consumer awareness and risk perception are cited as another important barrier where the consumers are alien to the new technology and perceive them to be a risky investment. As the high upfront cost of the product is a major obstacle, affordability is another significant issue in the SHS market. The "institutional aspects" form a major barrier to the dissemination of solar home systems as adequate policies and regulatory bodies are absent and are not functioning properly. Limited knowledge of technology and lack of trained personnel and training institutes pose a threat to the diffusion process. Lack of financing options and high investment required are the primary barrier which came up in this adaptation process and was cited multiples times in various literature sources. A significant barrier "Business knowledge" was added to the framework which is indeed pertinent in the current research as it sheds light on the business acumen required to run an organization.

2.3.2. Adaptation (Stage 2)

Table 2-13 gives the second level of adaptation to the Ortt *et al.* framework. This table is derived from the first level of adaptation and the literature on diffusion of solar home systems in developing countries. The new factors which are added to the Ortt *et al.* framework and the additional information which is

added to the description of existing factors are colored in orange. An important factor added in this adaptation is the lack of business knowledge among organizations which impacts their business activities. This is due to improper management, lack of strong marketing network and lack of successful business models in the surrounding. This factor is placed under influencing factors as it directly impacts the business operations which further affect the availability of customers and complimentary products and services.

Table 2-13 Adapted Influencing & core factors (Gaurav Manchanda, 2017)

Indirect (Influencing) factors	Direct (Core) factors
Knowledge of technology *Same as in original*	***New high-tech product (cost)*** *High capital cost*
Knowledge of application *Same as in original*	***Production system*** *Original + Lack of O&M facilities*
Natural resources and skilled personnel *Original + Lack of skilled personnel*	***Complimentary products & services*** *Underdeveloped supply channels, lack of after sales services + lack of established dealer network, lack of technical support for installation and maintenance, spare parts and PV module availability*
Socio-cultural aspects *Original + Poverty, low education level, credit risk and collection concerns + Lack of local stakeholders in decision making, lack of involvement of local communities in program design*	***Suppliers (manufacturers and vendors of raw material, spare parts)***
Macroeconomic aspects *Same as in original*	***Customers*** *Same as in original*
Accidents or events *Same as in original*	***Institutional aspects (laws, rules & standards)*** *Original + Lack of adequate government policies, lack of institutional capacity, lack of information to companies on market scenario + stiff competition from conventional energy*
Affordability *Lack of paying capacity, no income generation*	***Consumer awareness & risk perception*** *Lack of consumer awareness, high-risk perceptions, misperceptions*
Infrastructure *Lack of infrastructure such as roads*	***Financial*** *Lack of financing mechanisms for consumers and lack of access to capital for companies*
Environmental *Local pollution, ecological issues, use of hazardous materials during production*	
Political *Lack of political commitment, widespread corruption*	
Business knowledge *Inadequate business knowledge, lack of successful business models*	

In *figure 2-6*, the factors which are adapted in the Ortt *et al.* framework are categorized according to the level of adaptations mentioned in *figure 2-3*. The eight completely new factors which are placed under level 5 are affordability, infrastructure, environmental, political, consumer awareness, financial and business knowledge. The factor which is redefined and placed under level 3 is suppliers as it is redefined. Skilled personnel were earlier missing in the original framework definition of natural resources and hence adapted under level 2 where the factor description changes. The production system description is enriched with the inclusion of lack of O&M facilities and hence adapted under level 2. The description of complimentary products & services is enriched by specifying the "distribution" and "use" factors which are underdeveloped supply channels, lack of established dealer network and after sales service. This is adapted under level 2. The institutional aspects description is also enriched by specifying certain barriers which are lack of adequate government policies and stiff competition from conventional energy. This is also modified under level 2. The socio-cultural aspects description is specified clearly with more factors which are poverty, payment issues, credit risk and collection concerns. This also comes under level 2 of adaptation. The new high-tech product is adapted under level 1 as the high price component is more important than other components.

Level 5 Completely new factor	**Level 4 New factor within existing generic factor**	**Level 3 Factor is redefined**	**Level 2 Factor description changes**	**Level 1 Sub-element of the factor is more important**
Affordability Infrastructure Environmental Political Consumer awareness Financial Business knowledge		Suppliers	Production system Complimentary products and services Institutional aspects Socio-cultural aspects Natural resources	New high-tech product

Figure 2-6 Ortt et al. framework adapted according to the adaptation levels

2.4. Identification of strategies

2.4.1. Strategies from Ortt *et al.* literature

Table 2-14 presents with a list of ten niche strategies for complete diffusion of the new high-tech product for different market situations. The market situations are derived from the combination of influencing and core factors mentioned in theory. The strategy is briefly described in column 3, and the associated market situation is described in column 2 (Ortt *et al.* 2013).

Table 2-14 List of strategies (Ortt *et al.* 2013)

Generic Niche Strategy	Market situation	Description of the strategy
Demo, experiment & develop niche strategy	Knowledge of the technology is lacking and that affects the availability of the product itself because the functionality is not provided with sufficient **quality**.	Demonstration in a controlled environment and development of product through research
Top niche strategy	Knowledge of the technology is lacking and that affects the availability of the product for a reasonable **price**.	Products can be handmade for the top niche of the market Top niche is supplied with a special product on priority
	Knowledge of the technology is lacking and that affects the production system with which controlled production of products with a constant and good enough **quality and reasonable price** is possible.	
	Resources for the product or the production are lacking or very expensive and that affects the product's **price**.	
Subsidized niche strategy	Knowledge of the technology is lacking and that affects the availability of the product or the production system and that in turn affects the availability of the product for a reasonable **price**.	The product is subsidized if a certain segment of consumers is considered as societally relevant
	Resources for the product or the production are lacking or very expensive and that affects the product's **price**.	
Redesign niche strategy	Knowledge of the technology is lacking and that affects the availability of the product or the production system and that in turn affects the availability of the product for a reasonable **price**.	Introduced in a simpler version with existing knowledge and resources and therefore for a lower price
	Resources for the product or the production.are lacking or very expensive and that affects the product's **price**.	
	Knowledge of the application of the product is missing or socio cultural aspects affect the availability of appropriate	To explore an application where institutional aspects are favorable

	institutional aspects (laws, rules and standards) and thereby hamper diffusion.	
	Socio-cultural aspects affect the availability of suppliers or customers.	To explore an application where there is no resistance to produce or use
Dedicated system or standalone niche strategy	Knowledge of the technology is lacking and that affects the availability of complementary products and services.	When the required infrastructure is lacking, the product can be used in a standalone mode or with dedicated complimentary products and services
Hybridization or adaptor niche strategy	Knowledge of the technology is lacking and that affects the availability of complementary products and services.	The new product can be used in combination with the old product and use the existing products and services
	Resources are lacking and that affects the availability of complementary products and services.	
Educate niche strategy	Knowledge of the technology is lacking and that affects the availability of suppliers or customers	Transfer of knowledge to suppliers via conferences and this strategy is also aimed at increasing customer knowledge
Geographic niche strategy	Knowledge of the technology or its application is lacking and that affect the availability of appropriate institutional aspects (laws, rules and standards)	It can be adopted where laws and regulations are easy to arrange or are less strict
	Resources are lacking affecting the availability of the product or complementary products and services.	Operations to be shifted to another location where resources, suppliers, customers are easily available
	Socio-cultural aspects or macroeconomic aspects affect the availability of suppliers, customers and appropriate institutional aspects.	
	Accidents and unexpected events affect the availability appropriate institutional aspects.	Adopted in another location where suppliers are easily available and are not hampered by unexpected events
Lead user niche strategy	Knowledge of the application of the product is missing, and that affects a clear view on customer applications, specific product requirements and customer segments by suppliers.	Lead users or innovators are co-developing the product. For instance, top sportspersons are developing their equipment themselves
	Socio-cultural aspects, Macro-Economic aspects or accidents and unexpected events affect the availability of suppliers or customers.	
Explore multiple markets niche strategy	Knowledge of the application of the product is missing, and that affects the availability of a clear view on applications, usage patterns and product benefits by customers.	Multiple customer applications can be explored

2.4.2. Strategies from developing countries literature

Table 2-15 provides with strategies adopted for various barrier situations from various literature sources on developing countries. The barriers found in the literature are mentioned in column 1, and the associated strategy is presented in column 2. Column 3 indicates the source of the strategy. Some of the barriers do not have any strategy mentioned in literature; their empty cells are painted blue in color.

Table 2-15 Combined list of strategies from literature on developed countries

Barriers addressed	Strategy	Source
New high-tech product	Introduce credit scheme. Repayment of the load should correspond closely to the amount of money served from using kerosene, candles, and torches	(Kweka *et al.* 2011)
	Research & development	(Painuly 2001)
	R&D for cost reduction	(Yaqoot *et al.* 2016)
Production system		
Complimentary products & services	Build a network of dealer	(Kweka *et al.* 2011)
	Training users and technicians to facilitate proper maintenance through demonstration systems	(Barua *et al.* 2001)
	After sales services infrastructure for training and extension programs	(Yaqoot *et al.* 2016)
Infrastructure		
Suppliers		
Customers	Providing technology to customers according to their needs	(Barua *et al.* 2001)
Consumer awareness & risk perception	Increase understanding of solar PV technology to the large community via media and personal networking	(Kweka *et al.* 2011)
	Volume of interest created via demonstration systems	(Barua *et al.* 2001)
	Conduct consumer awareness and marketing programs	(Martinot *et al.* 2001)
	Information & awareness campaigns	(Painuly 2001)
	Awareness generation or information dissemination programs	(Yaqoot *et al.* 2016)
	Demonstration programs	(Yaqoot *et al.* 2016)
	Targeting affluent customer base as early adopters	(Karakaya & Sriwannawit 2015)
Affordability	Subsidize promotion of solar technology	(Kweka *et al.* 2011)
	Providing technology to customers according to their financial status	(Barua *et al.* 2001)
Institutional aspects	Lobby government to shape institutional environment	(Jolly *et al.* 2012)
Knowledge of technology	Training selected community member to size, install and repair solar	(Kweka *et al.* 2011)
	Research & development	(Painuly 2001)
Natural resources & labor		
Knowledge of application		
Socio-cultural aspects	Comprehensive assessment of the perceived needs of the end user	(Yaqoot *et al.* 2016)

	Involvement of local stakeholders in planning and promotion of DRES	(Yaqoot *et al.* 2016)
	Demonstration programs	(Yaqoot *et al.* 2016)
	Barefoot approach[1]	(Kweka *et al.* 2011)
	Involvement of local stakeholders in planning and promotion of DRES	(Yaqoot *et al.* 2016)
Macroeconomic aspects		
Accidents or events		
Financial & high investment	Formulate micro credit scheme	(Kweka *et al.* 2011)
	Introduce credit scheme. Repayment of the loan should correspond closely to the amount of money served from using kerosene, candles, and torches	(Kweka *et al.* 2011)
	Use of micro-credit schemes	(Barua *et al.* 2001)
	Assistance from government and donors	(Cabraal *et al.* 1996)
	Pay first-cost subsidies and offer affordable system sizes	(Martinot *et al.* 2001)
	Consumer Credit (innovative finance mechanisms along with dealers and microfinance organizations, for instance, Grameen Shakti)[2]	(Martinot *et al.* 2001)
	Innovative financing mechanisms	(Yaqoot *et al.* 2016)
	Micro-credit facilities	(Yaqoot *et al.* 2016)
	Support from venture capital, private equity, international funding	(Liming 2009)
Political		
Environmental	Life cycle analysis	(Yaqoot *et al.* 2016)
	R&D for development of efficient systems with minimum possible footprints	(Yaqoot *et al.* 2016)
	Awareness generation among stakeholders	(Yaqoot *et al.* 2016)
Business knowledge	Build business knowledge and capacity for distribution of solar PV systems	(Kweka *et al.* 2011)
	Pilot private sector and NGO delivery models	(Martinot *et al.* 2001)

2.4.3. Adaptation of strategies in Ortt *et al.* framework

Table 2-16 gives the adapted and new definition of strategies in the Ortt *et al.* framework. Column 2 gives the original definition used in the framework and column 3 gives the adapted or completely new

[1] *Barefoot approach - This approach is aimed at providing hands on training to rural women who would gain skills of installation, repair and maintenance of solar lighting kits. This approach has benefited rural villages in 25 countries in Africa, Asia and Latin America. Barefoot approach provides skills to the illiterate women who even lacks formal education. These women have proved to be a role-model for their communities* (Kweka *et al.* 2011).

[2] *Grameen Shakti – This Bangladeshi project has been quite successful in providing credit services to customers. Grameen Shakti is an organization which performs marketing, sales, service, credit provision, collections and guarantees. The consumer credit loans are approximately 500USD for 3 years with 12 % interest rate. These loans are one-time and used to purchase solar home systems.*

definition of strategies. These definitions are derived from the strategies mentioned in literature on renewable energy systems in developing countries. The adaptations in these definitions are colored in orange. The subsidized niche strategy in the original framework is absorbed under access to finance strategy. It makes more sense for this adaptation as subsidizing a product is essentially providing access to finance. Access to finance has other elements and are discussed below.

Table 2-16 Adapting strategy definition for the original Ortt et al. framework

New/ Original Strategy	Original definition	Adapted/new definition
Demo, experiment & develop niche strategy	Demonstration in a controlled environment and development of product through research	Demonstration in a controlled environment and development of product through research
Top niche strategy	Products can be handmade for the top niche of the market. Top niche is supplied with a special product on priority	Products can be handmade for the top niche of the market. Top niche is supplied with a special product on priority.
Redesign niche strategy	Introduced in a simpler version with existing knowledge and resources and therefore for a lower price. To explore an application where institutional aspects are favorable. To explore an application where there is no resistance to produce or use.	Introduced in a simpler version with existing knowledge and resources and therefore for a lower price. To explore an application where institutional aspects are favorable. To explore an application where there is no resistance to produce or use.
Access to finance		The product is subsidized if a certain segment of consumers is considered as societally relevant. Introduce credit schemes and reduction in transaction cost (learning by doing), Formulate micro credit schems; Consumer Credit (innovative finance mechanisms along with dealers and microfinance organizations, for instance, Grameen Shakti) Providing technology to customers according to their financial status. Assistance from government and donors, Support from venture capital, private equity, international funding
Hybridization or Adaptor niche strategy	A niche strategy can be adopted by which the new product is used in combination with the old product and thereby all existing complementary products and services can be re-used. Or an adaptor/convertor is provided to make the product compatible with existing complementary products and services.	A niche strategy can be adopted by which the new product is used in combination with the old product and thereby all existing complementary products and services can be re-used. Use existing and build network of dealers for distribution of SHS

Educate niche strategy	A niche strategy can be adopted aimed at transferring the knowledge to suppliers. An educate and experiment (pilot) niche strategy can be adopted aimed at increasing customer knowledge.	A niche strategy can be adopted aimed at transferring the knowledge to suppliers. An educate and experiment (pilot) niche strategy can be adopted aimed at increasing customer knowledge. Media/personal networking, awareness and marketing campaigns, demonstrations systems Training users and technicians to facilitate proper maintenance through demonstration systems
Geographic niche strategy	It can be adopted where laws and regulations are easy to arrange or are less strict. Operations to be shifted to another location where resources, suppliers, customers are easily available. Adopted in another location where suppliers are easily available and are not hampered by unexpected events.	It can be adopted where laws and regulations are easy to arrange or are less strict. Operations to be shifted to another location where resources, suppliers, customers are easily available. Adopted in another location where suppliers are easily available and are not hampered by unexpected events.
Lead user niche strategy	Lead users or innovators are co-developing the product. For instance, top sportspersons are developing their equipment themselves	Lead users or innovators are co-developing the product. For instance, educated people in the village
Explore multiple markets niche strategy	Multiple customer applications can be explored.	Multiple customer applications can be explored. For instance, in the form of different appliances to be used with the solar home system.
After sales service		after sales services infrastructure for training and extension programs
Lobbying		Lobby government to shape institutional environment
Participation niche strategy		Involvement of local stakeholders for instance the barefoot approach, Involvement of NGO's and private dealers
Environmental measures		Life cycle analysis; R&D for development of efficient systems with minimum possible footprints

2.5. Linkage of market situations with combined strategies from literature

Table 2-17 specifies different set of market conditions based on the combination of influencing and core factors are linked to strategies mentioned in literature. This mapping is based on the Ortt *et al.* framework which describes several market situations linked to niche strategies (Ortt *et al.* 2013). The new market situations from literature are marked in yellow.

The lack of knowledge of technology and application hampers consumer awareness and affects the availability of financial services and instruments for both consumers and companies. Affordability of the consumer is another major factor cited in literature which affects the availability of customers due to lack of finance. The lack of business knowledge hampers the reach to consumers due to an ineffective business model and a weak value proposition. It also affects the complimentary products and services as there is uncertainty in the product distribution mechanism. The lack of local stakeholder involvement which is a sub-element of socio-cultural aspects could hamper the availability of customers as it is indeed important to include them in decision making for sustainable growth. The local community members are generally hesitant to adopt the product and technology as they lack trust in it and especially lack trust in the outsiders. Therefore, by engaging the local community members, trust can be built and thus adopting the technology (Nicole van den Berg, 2017). The lack of stakeholder involvement under socio-cultural aspects can also hamper the availability of complimentary products and services in the form of distribution channels and aftersales service network. Lack of good infrastructure facilities hampers the production system and complimentary products and services as the supply chain and logistics facilities are affected in absence of good road/rail and communication network. The environmental barriers hamper the production system due to the ecological concerns with manufacturing. The lack of resources in the form of skilled labor can affect the complimentary products and services such as an effective after sales services network.

Table 2-17 Market situations from literature linked to niche strategies

Generic Niche Strategy	Influencing factors	Core factors
Demo, experiment & develop niche strategy	Knowledge of technology	New high-tech product
Top niche strategy	Knowledge of technology	New high-tech product
	Knowledge of technology	New high-tech product Production
	Natural Resources	New high-tech product
	Knowledge of technology Knowledge of application	Consumer awareness & risk perception
Access to finance	Knowledge of technology Knowledge of application	Financial (consumer)
	Knowledge of technology	New high-tech product (cost)
	Affordability	Customers
	Knowledge of technology Knowledge of application	Financial (companies)
	Knowledge of technology	New high-tech product Production
	Natural Resources	New high-tech product
Redesign niche strategy	Knowledge of technology	New high-tech product Production
	Natural Resources	New high-tech product
	Knowledge of application Socio-cultural aspects	Institutional aspects
	Socio-cultural aspects	Suppliers

		Customers
Dedicated system or standalone niche strategy	Knowledge of technology	Complimentary products & services
Hybridization or adaptor niche strategy	Knowledge of technology	Complimentary products & services
	Resources	Complimentary products & services
Educate niche strategy	Knowledge of technology	Complimentary products & services
	Knowledge of technology	Suppliers Customers
	Knowledge of technology Knowledge of application	Consumer awareness & risk perception
	Business knowledge Socio-cultural aspects	Customers
Geographic niche strategy	Knowledge of technology Knowledge of application	Institutional aspects
	Natural Resources	New high-tech product Complimentary products & services
	Socio-cultural aspects Macroeconomic aspects	Suppliers Customers Institutional aspects
	Accidents or events	Institutional aspects
Lobbying	Knowledge of technology Knowledge of application	Institutional aspects
Participation niche strategy	Business knowledge Resources Socio-cultural aspects	Complimentary products & services
	Business knowledge Socio-cultural aspects	Customers
Lead user niche strategy	Knowledge of application	Customers
	Socio-cultural aspects Macroeconomic aspects Accidents & events	Suppliers Customers
Explore multiple markets niche strategy	Knowledge of application	Customers
Environmental measures	Environmental aspects	Production
Aftersales services	Resources	Complimentary products & services

2.7 Business Model Canvas

"A business model describes the rationale of how an organization creates, delivers and captures value." (Osterwalder *et al.* 2010)

A business model can be best described using nine building blocks in the form of a business model canvas. The BMC shows the logic of how a company operates and what it has to offer. These nine elements are as defined in the first chapter are **Customer Segments, Value Proposition, Channels, Customer Relationships, Revenue Streams, Key Resources, Key Activities, Key Partners and Cost Structure.** These nine building blocks are defined and described subsequently. *Figure 2-7* is a typical business model canvas as it bears a resemblance to a painter's canvas which has pre-assigned nine blocks.

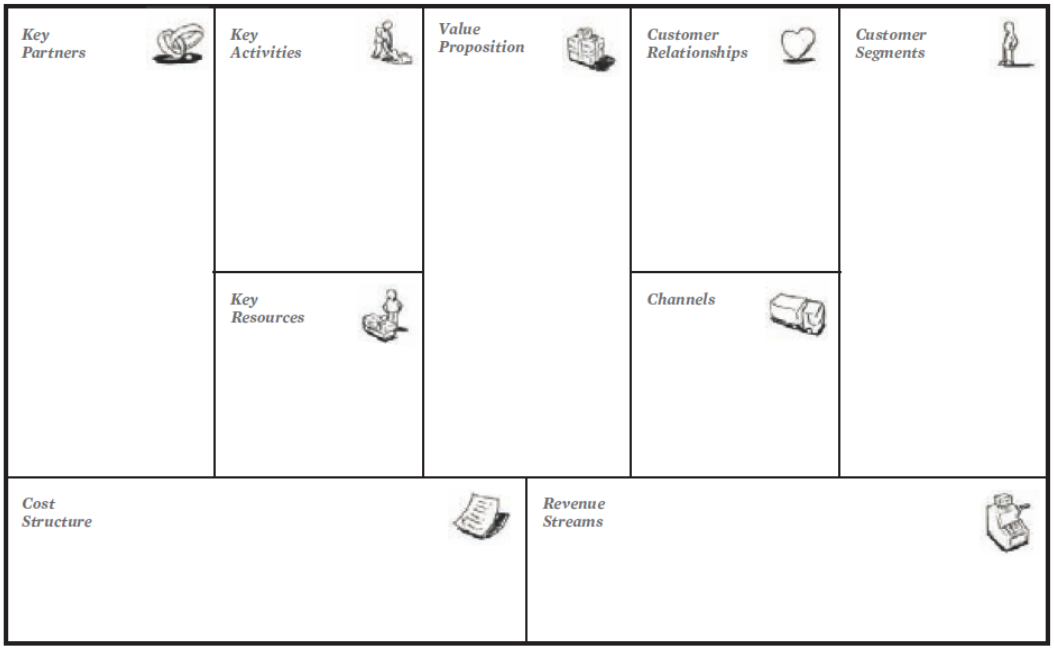

Figure 2-7 Business Model Canvas (Osterwalder et al. 2010)

Customer Segments

The heart of any business model are the customer segments which a company aims to serve. The customer segments must be grouped together characteristically according to the consumer needs and behavior. For instance, the niche markets which have specific set of customer segments with specific needs, in that case, the value proposition, the distribution channels and customer relationships are tailored to the particular requirements.

Value Proposition

VP is a bundle of products and services offered to the customer segments and creates value for them. An innovative and a disruptive VP can push the customer to move from the existing VP to a new one. The value created for them can be measured both quantitatively (price and speed of services) and qualitatively (product design and technology, customer satisfaction).

Channels

The channels are described as a platform through which a company communicates and delivers the value proposition to its customer segments. The channels are either owned by the company or by the partner. Channels could be the form of salesforce, web sales, own stores, partner stores or wholesaler.

Customer Relationship

CR describes the type of relationships a company establishes with various customer segments. The different types of relationships could be of the form of personal assistance, dedicated personal assistance, self-service, automated services, online communities and co-creations (writing reviews online).

Revenue Streams

R$ describes how a company generates revenues from different customer segments. There are different ways to generate revenue which is asset sale (selling the physical product), usage fee (for instance, telecom operator), subscription fee (for instance gym fee), lending/renting/leasing, licensing, brokerage fee and advertising.

Key Resources

These are described as the most important assets to make a business model work. These can be either physical, intellectual, human and financial.

Key Activities

KA are the most important tasks a company must do in order to successfully deliver the value proposition, maintain customer relationships and earn revenues. Key activities include production, problem-solving (consultancies) and platform/network (development of the platform ebay.com).

Key Partners

KP describes the network of suppliers and partners that make a business model work. These partnerships could be *strategic alliances between non-competitors, Coopetition (strategic partnerships between competitors), Joint ventures to develop new business and buyer-supplier relationship.*

Cost Structure

C$ is described as all the costs incurred to operate a business model. These costs are categorized as fixed costs, variable costs, economies of scale (cost per unit falls as the company expands) and economies of scope (same marketing activities or channels can support various products).

2.7.1. Business model canvas for a typical Solar Home System player in India

This BMC is built based on several kinds of literature studied related to SHS in India and a brainstorming session with a group of friends. The nine elements are clearly indicated with the relevant information described in *figure 2-8*. This BMC is pertinent to our study as it would be a useful asset in defining the linkage between various market situations and strategies in the subsequent section. This BMC would be used only to study the linkage and is not an indicator of the exhaustive form of the canvas for SHS players in India.

The key partners are the suppliers, local dealers, salesmen, local stakeholders and regulatory bodies whereas the key resources are company's employees, their manufacturing facility and the technology patents owned. Marketing, publicity, manufacturing of goods, procurement of raw material or spare parts, installation and after sales services are the the key activities to be performed. The value proposition could be various forms of innovative service and delivery models and the financing options. Involvement of local stakeholders and regular meetings with customers are under customer relationships. The customer segments to be targeted are the rural population with no or limited access to electricity. The key channel through which the customer segments can be reached is through field sales. The cost which the company incurs is in manufacturing & procurement, research & development, employee salaries, logistics cost and commission to dealers. The company makes revenue from the sale of SHS, its spare parts, and its service cost.

<table>
<tr><td rowspan="2">Key Partners
Supplier (PV module, charge controller, lighting, others)
Local dealers & salesmen
Local stakeholders
Regulatory stakeholders</td><td>Key Activities
Marketing & publicity
Manufacturing/procurement
After sales service/installation</td><td rowspan="2">Value Proposition
Innovative financing option (microfinancing, pay as you go, progressive purchase model)</td><td>Customer Relationships
Involvement of local stakeholders
Regular group meetings with customers</td><td rowspan="2">Customer Segments
Rural population with limited access to electricity
Rural population with no access to electricity</td></tr>
<tr><td>Key Resources
Employees
Manufacturing facility
Technology patents
Financial instruments</td><td>Channels
Field sales through local dealers & salesmen
Website</td></tr>
<tr><td colspan="3">Cost Structure
Manufacturing & procurement, Research & development
Employee salaries, Logistics cost, Commission to dealers</td><td colspan="2">Revenue Streams
Sales of SHS, Sale of spare parts Service cost</td></tr>
</table>

Figure 2-8 BMC for a typical SHS player in India

2.8. Linkage between niche strategies and the elements of BMC

The linkage between barriers, niche strategies and business model canvas elements can be described in two ways. The first method is to explicitly define the strategies with the help of BMC elements. This is done as the current definitions are meagre in nature. The second method is to use the BMC tool to analyze the effect of strategies. The second is particularly important in understanding the implications of the strategies on the BMC elements. In this project, the second method is used to define the relationship between strategies and BMC elements as shown in *figure 2-9*. The effect of the strategies identified on the BMC is analyzed by the author and described in *table 2-18*. The elements of BMC in columns are matched to strategies in rows and the matched cells are highlighted in dark yellow color.

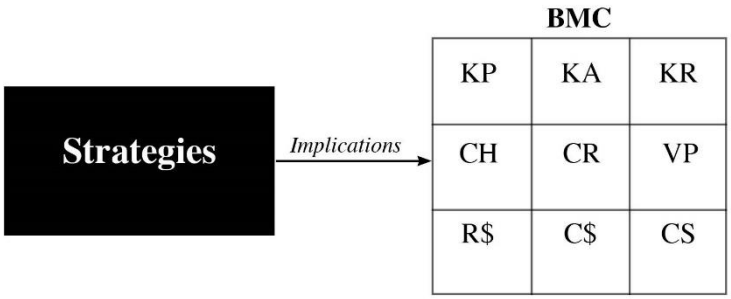

Figure 2-9 Implication of strategies on business model elements

The ***demo, experiment and develop strategy*** focuses on product development through research. This helps in developing a quality product which is also a key resource for the company. Hence, through this strategy, the key resource is developed. However, there is some cost incurred in the research & development process and hence also affects the cost structure of the company. This strategy also incorporates product demonstration in a controlled environment. During its implementation, the value proposition is tested for the demonstration activities. The ***top niche strategy*** is defined as selling the product to the top niche segment of the market. The top customer segment is targeted first in this strategy. The ***access to finance strategy*** is important for both companies and consumers. When the

consumers get financial access, they can buy the technology product. Hence in this way the customer segments are increased which also increases the revenue streams. The key partners are developed in the form of micro finance organizations who provide micro finance to the consumer. In certain cases, the value proposition is strengthened when the company offers a financing option with the product. When the company receives financial capital from international donors and investors, these financial instruments in the form of key resources are developed. Also, these funding organizations are developed as key partners for the company. The ***subsidized niche strategy*** makes available the product at a reasonable price. When the company bears the cost of subsidy, its cost structure is affected. But on the other hand, due to lower price, the customer segments increase which also improves the revenue streams. The ***redesign niche strategy*** makes the product available with existing knowledge and less use of resources and therefore for a lower price. This affects the value proposition of the company as the product is introduced in a simple version with lesser features where the institutional aspects are less strict and suppliers and customers have no resistance. This helps in building the customer segments and therefore revenue streams. The supplier relation is also maintained in an application where they have no resistance. These suppliers are developed in the form of key partners of the company. The ***dedicated system or standalone niche strategy*** allows the product to be used in a standalone mode when the complimentary products and services are not available. The product is not used up to its full potential for instance telephony was used as a burglar alarm when the infrastructure was not yet available. This affects the value proposition of the product as the product is now being introduced with limited features in a dedicated environment. The ***hybridization or adaptor niche strategy*** allows the company to use existing network of dealers for product distribution. These existing distributors are developed as key partners of the company and also contribute to additional channels to reach the customer. Due to this, the consumer segments increase and the revenue streams rises. The ***educate niche strategy*** is used to educate and train users, employees and suppliers. The customers are trained under marketing campaigns and demonstration systems. This helps in building a customer base and increased revenues and along with that, the customer relationship is strengthened. The technician (or employee) training is important to impart relevant skillset and increase the productivity. This helps in developing the key resource which is the employee in this case which leads to better key activities (after sales service) on ground. The ***geographic niche strategy*** allows the company to expand in other regions where the conditions are favorable. It helps in building new customer segments where there is no resistance. This way, the revenues are also increased. The key partners are developed in the form of suppliers which are added to the BMC. ***Lobbying*** helps in performing the key activities such as selling, production and marketing at ease with better institutional rules and regulations. ***The participation niche strategy*** involves local stakeholders and NGO's to be the part of the eco-system of the company. The key activities (installation and maintenance) are improved with the strategy and the NGO's are developed as the key partners of the company. Due to this strategy, the socio-cultural barriers are removed due to involvement of local stakeholders and hence the customer segments increase with increased revenues. Customer relationship is also developed with the help of local stakeholders and NGO's. The ***lead user strategy*** allows a company to experiment with the product and develop through lead users or innovators. The lead users help in developing the product which is a key resource for the company. These users act as key partners for the company who are willing to co-develop the product. The ***explore multiple markets niche strategy*** focuses on exploring multiple applications when the knowledge of application is not there. This helps in strengthening the value proposition where the product can be offered in multiple applications and helps in building a customer base which also increases the revenue streams. The ***environmental measures strategy*** involves life cycle analysis and R&D of efficient systems which helps in building a quality product that is the key resource for a company. The key activity such as production is improved with this strategy. Through ***after sales service***, customer relationships are strengthened, it forms a part of key activities and customer segments and revenue streams are maintained by providing them with excellent aftersales support.

Table 2-18 Implication of market situation-strategy on elements of BMC

Strategy / BMC	CR	VP	KA	KP	CS	R$	C$	CH	KR
Demo, experiment & develop niche strategy		■					■		■
Top niche strategy					■				
Access to finance		■		■	■	■			■
Subsidized niche strategy					■	■	■		
Redesign strategy		■		■	■	■			
Dedicated system or standalone niche strategy		■							
Hybridization or adaptor niche strategy				■	■	■		■	
Educate niche strategy	■		■		■	■			■
Geographic niche strategy				■	■	■			
After sales service	■		■		■	■			
Lobbying			■						
Participation niche strategy	■		■	■	■	■			
Lead user niche strategy				■					■
Explore multiple markets niche strategy		■			■	■			
Environmental measures			■						■

CR *Customer Relationship,* ***VP*** *Value Proposition,* ***KA*** *Key Activities,* ***KP*** *Key Partners,* ***CS*** *Customer Segments,* ***R$*** *Revenue Streams,* ***C$*** *Cost Structure,* ***CH*** *Channels,* ***KR*** *Key Resources*

CHAPTER 3 CASE STUDIES, EXPERT INTERVIEWS & FIELD STUDY

3. SHS Case Studies, Expert interviews & Field study

Introduction

There are various companies venturing into the rural electrification market in India with innovative technologies and products. Interviews with experts from three companies namely Simpa Networks, Rural Spark and Philips were conducted. Additional expert interviews from this sector were also performed to gain insights into the market. These experts are from organizations such as Mr. Keepi Foundation, Boond and Bridge to India. The field study was conducted in rural areas of Uttar Pradesh, India in association with Simpa Networks. The insights from these companies and experts are analyzed and discussed in this chapter. Simpa Networks has its operations in the state of Uttar Pradesh, Rural Spark is active in Uttar Pradesh & Bihar and Philips has pan India operations.

Figure 3-1 Companies selected for case studies

Methodology

An extensive list of companies operating in the solar home system market in India was prepared and contacted for expert interviews. Three companies were interested to participate in the interview sessions which are mentioned in *figure 3-1*. The interviews were conducted telephonically, through email and personally in the company's office in India. In addition to these case studies, several experts in this field were contacted for their insights into the solar home system market. These interviews are carefully examined and analyzed in this chapter. Before conducting the interview, the reports and data available online were studied to understand the company operations in an efficient manner. The interviewee was provided with a detailed questionnaire pertaining to questions on barriers, strategies and business model elements. (See appendix C for questionnaire) This questionnaire is divided into open and closed questions on barriers, strategies and BMC elements. The interview results are categorized according to the framework developed in the previous chapter. The effect of each strategy is discussed explicitly on the BMC elements. These interviews are conducted both in English and Hindi language as per the convenience of the interviewee.

3.1. Simpa Networks

"Think big, constantly innovate processes and offering to achieve scale, do not be afraid to take risks" ~ Piyush Mathur, CEO Simpa Networks

Table 3-1 Company Profile (Simpa Networks)

CEO	Piyush Mathur
Address	Simpa Energy India Pvt. Ltd. Fourth Floor, B-2, Sector 4, Noida, Uttar Pradesh, 201301, INDIA
Contact	info@simpanetworks.com
Contact Persons	Piyush Mathur, Mitali Sahni, Vidyut Mohan
Website	http://simpanetworks.com/

3.1.1. Introduction

The core activity of the company is to sell solar power systems to rural households and local shops based on an innovative financing mechanism. This financing mechanism is based on progressive purchase from small payments for usage up to owning the entire system. The consumer has to make a small down payment and then follow the pay as you go model and once the consumer has paid enough to own the system, the device unlocks permanently for use. The consumers then avail electricity from the solar panels for free. Simpa uses a patented pre-paid metering and control technology. One of the key USP's of Simpa is that it creates employment in rural areas by employing direct sales channels for their products. *Figure 3-2* graphically explains the journey from installation to topping up the energy and finally unlocking permanently for use and owning the system.

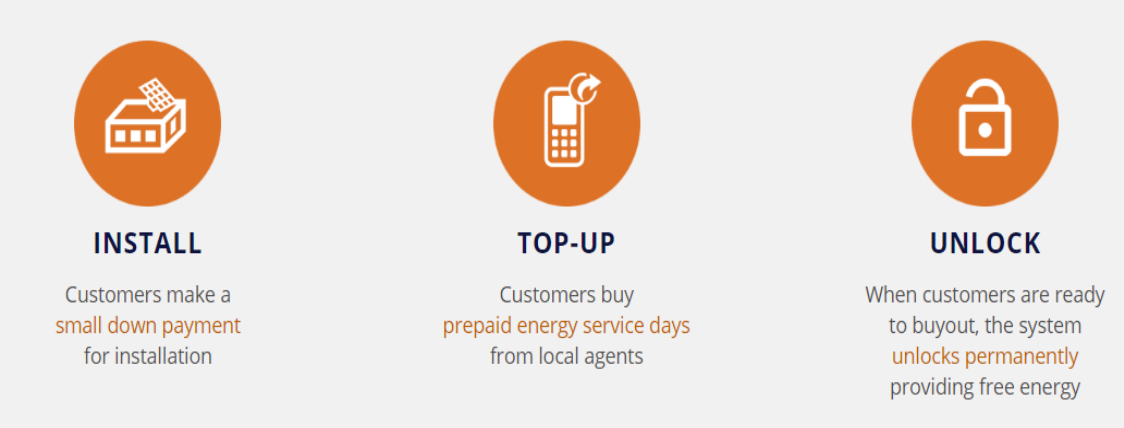

Figure 3-2 Simpa Networks modus operandi (SimpaNetworks n.d.)

3.1.2. Simpa's product range

Simpa offers six products in its portfolio. One of the products is SP Inverter which comes with a 200Wp solar panel and a priority charge controller. This product can be grid connected and connected to an existing battery backup and inverter. The battery backup can then be charged with the grid and solar on priority basis. The other products are Turbo Classic Turbo 240 which come with 60Wp and 80Wp panel respectively. The appliances which come with these systems are a DC fan, LED lights and mobile charging ports. Recently, a new product was launched by the company which is the Magic TV which in addition to the above-mentioned appliances comes with a 20-inch LED TV.

SP 50	50W panel with stand+6 mtrs. solar wire
SP 100	100W solar panel with stand +10mtrs.solar wire
Turbo Classic	60W Solar Panel + 10W Fan + 2 LED light + 17Ah battery + 2 USB mobile charging ports
Turbo 240	80W Solar panel + 15W fan + 26Ah battery + 3 LED lights + Battery Box with ccu
SP Inverter	200W Solar panel with stand + 20 Amps PCU (priority controller unit) + 10 mtrs. solar wire
Magic TV	80W Solar panel + 26Ah battery + 2 LED lights + 20 inches LED T.V. with Inbuilt set top box + 2 USB mobile charging ports + Battery Box with ccu

Figure 3-3 Simpa Networks Product Range

3.1.3. Closed and open questions to the Simpa Networks team

Table 3-2 Interview results: Simpa Networks

Questions		Quotes
Interviewees		Simpa Team
Open questions on barriers	Consumer awareness	Customer Awareness (to educate them), Still using kerosene, they haven't really opened their minds towards solar energy
		Awareness is a big challenge
	Skilled personnel	Finding lower/middle management talent (lack of skilled workers in rural areas.)
	High cost & lack of financing options for end-consumers	*The customers belong to a segment with low affordability and the alternatives available for them in the market have a high up-front cost.*
Closed questions on barriers	Financial	For companies – it is not really a barrier, the needs and capital requirement are quite limited
	Institutional aspects	*Regulations have not caught up the market yet*
		We want to convey that the central and state government is supportive of solar technology and has supportive policies. Simpa works on a sustainable business model where it has not avail any subsidy on its products which existed in the past.
	Production	*Manufacturing is not an issue*
	Supply chain & distribution	*Warehouses, enough stock (supply chain – no problem)*
	Socio-cultural aspects	*Revenue collection is very big challenge* *A lot of customers have electricity but is not reliable. There are not used to pay because there is no legal connection*
		93% customer are paying. In some cases, they need a bigger system then the old system is taken and large system is provided
Open questions to strategies	Access to finance	Through technology intervention and greater payment assurance; convince mainstream banks to start financing the customers directly; inspire

		confidence to mainstream banks, they need to understand the risk (the customer always pays in this case)
	Technology	Clever piece of technology to monitor SHS deployed, if the customer stops paying, it makes the system unusable; mobile prepaid model
	Awareness activities	Awareness by engaging people Sales people recruit urja mitras who bring the customers
	Educating the employees	Automating the processes, they bring down their expectations. They train them and semi train them, they provide them with management toolkits
	Participation of local stakeholders	*Urja mitras are employed from local villages, influential person (phone recharge shop, meeting people on regular basis)*
Closed questions to strategies	Access to finance	*Partnership with mainstream banks (directly giving loans to customers) – no other off grid company has achieved*
	Demo, experiment & develop	*Awareness activities, display systems, field officers*
Closed questions to BMC	Key partners	Key partners – product suppliers, financing value chain
	Cost structure	The costs are incurred in product, awareness building costs a lot of money, building distribution network
	Channels	Trying to extend arms for distributor (sales retail channel) through existing distribution network. Shops such as mobiles, electrical goods who are selling goods worth 3000 -10000 INR
Open questions on impact on BMC		*Urja mitras work on a commission basis from local villages, influential person (phone recharge shop, meeting people on regular basis).*

3.1.4. Barrier results

The interview with Simpa Networks team have been analyzed in the following section. A number of factors were identified during the interviews and in various reports related to the Simpa Networks operations. The key challenges faced by Simpa are low consumer awareness, lack of skilled workers in rural areas and financing for the consumers. People in the rural areas are still using kerosene, and they haven't altered their minds towards the solar technology. It is a big challenge to educate them about the solar technology and its benefits. The second barrier cited is finding the lower level and middle-level management personnel. The third challenge is a lack of financing mechanisms for the consumers as the traditional lending institutions do not understand the business dynamics. The text in green indicates no barrier to the business operation in *table 3-3*.

Table 3-3 List of barriers (influencing & core) faced by Simpa Networks

Indirect (Influencing) factors	Direct (Core) factors
Natural resources and skilled personnel Finding lower/middle management talent (lack of skilled workers in rural areas.)	***New high-tech product (cost & quality)*** Capital cost for consumers is very high

Socio-cultural aspects Revenue collection is a big challenge. A lot of customers have electricity but it is not reliable. They are not used to pay for electricity because they build illegal connections with the grid	***Production system*** Manufacturing is not an issue
Affordability Adoption & affordability is a challenge	***Complimentary products & services (distribution & use)*** Enough stock in warehouses (supply chain – no problem)
	Institutional aspects (laws, rules & standards) We want to convey that the central and state government is supportive of solar technology and has supportive policies. Simpa works on a sustainable business model where it has not avail any subsidy on its products which existed in the past. Regulations have not caught up the market yet
	Consumer awareness & risk perception Awareness is a big challenge Customer Awareness (to educate them), Still using kerosene, they haven't really opened their minds towards solar
	Financial The customers belong to a segment with low affordability and the alternatives available for them in the market have a high up-front cost For companies – it is not really a barrier, the needs and capital requirement are quite limited

3.1.5. Strategies

The interviews and case study exhibited strategies that are also a part of the identified strategies from literature. There are majorly four strategies identified from the interviews and reports. These are access to finance, hybridization or adaptor niche strategy, educate niche strategy and participation niche strategy which are explained in *table 3-4*. All the strategies implemented by the company are towards scaling up their operations.

Table 3-4 Strategies implemented by Simpa Networks

New/ Original Strategy	Adapted/new definition
Access to finance	-Equity investment from ADB (2$ million); Debt financing from OPIC and GDF Suez Rassembleurs d'Energies; International impact investors and development finance institutions. -Progressive purchase for consumers. -Partnership with mainstream banks for off-balance sheet financing– *"no other off grid company has achieved"*. -Through technology intervention and greater payment assurance, Simpa is convincing mainstream banks to start financing the customers directly; inspire confidence to mainstream banks, they need to understand the risk (the customer always pays in this case).
Hybridization or Adaptor niche strategy	Trying to extend arms for distribution (sales retail channel) through existing distribution network [Shops who sells goods worth 40 -150 EUR, the goods may be mobiles, electrical appliances].

Educate niche strategy	-Regular demos and surveys (building trust), relationship building. -Awareness activities, display systems through field officers. -Awareness by engaging people. Sales people recruit urja mitras (Village level entrepreneurs) who bring the customers. -Automating the processes, Simpa brings down their expectations and train/semi-train their staff, Simpa provides them with management toolkits.
Participation niche strategy	-Simpa is addressing customer concerns through its Urja Mitra system. Each Simpa VLE is a well-known individual: legitimate, accountable, and trusted within the community. When dealing with such recognized individuals, customers gain trust in the system. It helps in relationship building with the customers. -Urja mitras work on a commission basis from local villages, influential person (phone recharge shop, meeting people on regular basis).

3.1.6. Elements of Business Model Canvas

Table 3-5 presents an explorative and non-exhaustive set of business model elements obtained from expert interviews and relevant reports and articles. The *key partners* are suppliers of PV module, charge controller, lighting and other components of the SHS. *Key partners* also include international investors, ICT provider (Thoughtworks) and village level entrepreneurs who are called "Urja Mitras". The *key activities* are marketing, publicity, after sales services and installation. The *value proposition* is the innovative financing mechanism which is the progressive purchase model. The *customer relationships* are built through service channels, demonstration activties, and surveys. The *customer segments* are the rural population with limited or no access to electricity. The *channels* are direct sales channels who are on the payroll of Simpa and VLEs who work on commissions. The *key resources* of the company are employees, the patented technology, and financial instruments. The major costs incurred are in product building, awareness creation, and building distribution network. The *revenue streams* are through the sale of SHS and through monthly recharges of electricity.

Table 3-5 Elements of BMC (Simpa Networks)

<table>
<tr><td rowspan="2">Key Partners
Suppliers (PV module, charge controller, lighting, others)
Thoughtworks
International investors
Urja Mitras
RBL</td><td>Key Activities
Marketing & publicity
Product components procurement
After sales service/installation</td><td rowspan="2">Value Proposition
Progressive purchase model</td><td>Customer Relationships
Through service channels (Urja mitras), solar technicians, demos & surveys</td><td rowspan="2">Customer Segments
Rural population with limited access to electricity
Rural population with no access to electricity</td></tr>
<tr><td>Key Resources
Employees
Progressive purchase system {regulator (micro-controller) & revenue management system}
Financial instruments</td><td>Channels
Direct sales channel &
Village level entrepreneurs</td></tr>
<tr><td colspan="3">Cost Structure
procurement, research & development, employee salaries, logistics cost, commission to dealers, product, awareness building costs a lot of money, building distribution network</td><td colspan="2">Revenue Streams
Sales of SHS, Monthly recharges</td></tr>
</table>

3.1.7. Link between barriers, strategies and BMC elements

In this section, the relationship between barriers, strategies and BMC elements is studied. *Figure 3-4* graphically describes the relationship between barriers, strategies and BMC elements. The individual barriers are linked to the respective strategies as seen in *figure 3-5*. The effect of barriers on BMC elements is described briefly in *section 3.1.8*. The effect of strategies is explicitly defined in strategy-BMC linkages developed for Simpa Networks in *section 3.1.9*. These linkages bring clarity to the implications of the strategies on the business model canvas. The affected elements of BMC are clearly indicated in the strategy-BMC linkage *figures (3-7 to 3-12)*. These linkages and implications are analyzed by the author based on the case study interviews.

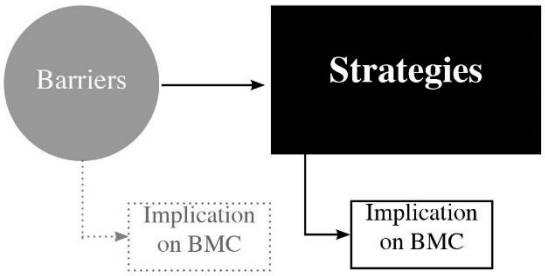

Figure 3-4 Link between barriers, strategies & BMC

In *figure 3-5*, the key barriers are linked to the respective strategies and are color coordinated. Non-affordability and high cost of SHS is linked to the access to finance strategy which is about the progressive purchase model in which the company provides the products on lease and then on pay-as-you-go (PAYG) basis to the end customer. The low consumer awareness is linked to the educate niche strategy which is about awareness building and finding lower/middle management talent is linked to the educate niche strategy for employees where they are given training and relevant skill sets are imparted.

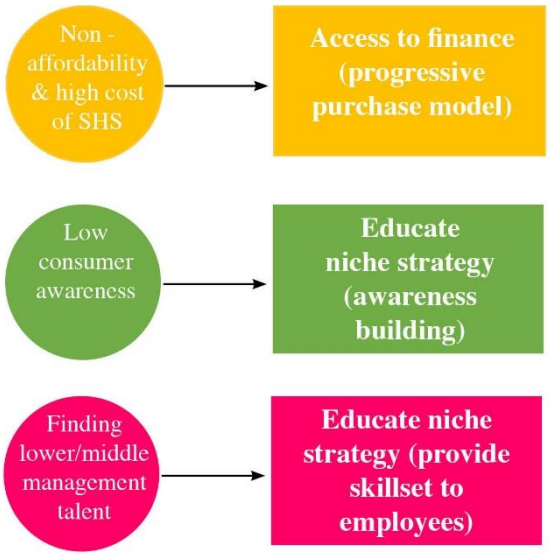

Figure 3-5 Barriers & strategies linkage for Simpa Networks

3.1.8. Implication of barriers on the business model canvas

Non-affordability and high cost of SHS impacts the availability of consumer segments, and hence the revenue streams are blocked. Low consumer awareness has a similar impact as there are *limited consumers* and *limited revenue*. Finding skilled personnel at lower and middle level is one of the main challenges for Simpa. The *key resources* which are employees of the company are affected due to this barrier. The interviewee also indicated that neither manufacturing is a problem nor supply of the products. The institutional regulations have not yet caught up the market and doesn't pose any complications for the company.

3.1.9. Implication of employing strategies on the business model canvas

The implications of each strategy on the business model canvas is discussed in this section in detail. Six main strategies are discussed as mentioned in *figure 3-6*.

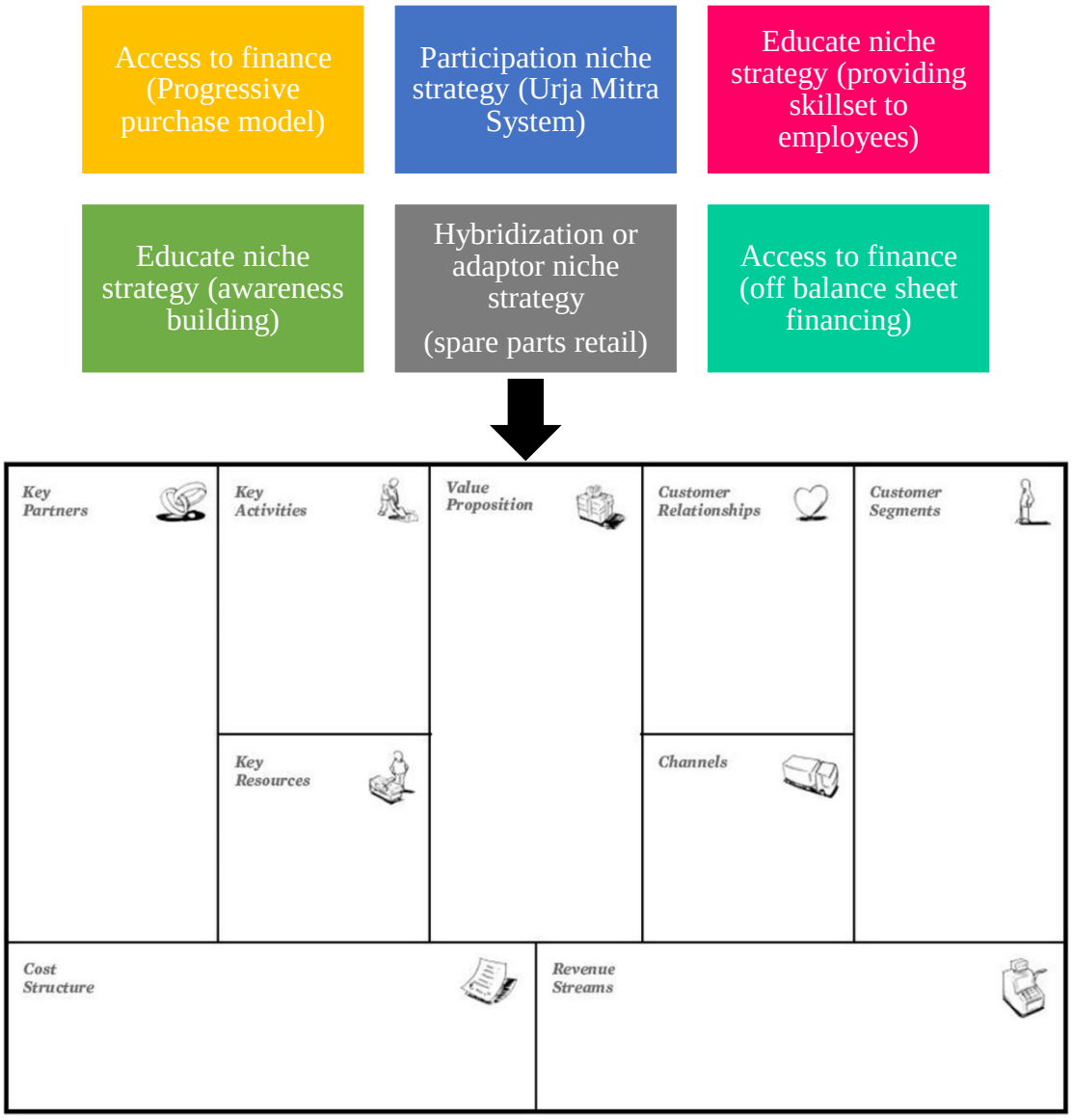

Figure 3-6 Effect of six strategies by Simpa on BMC

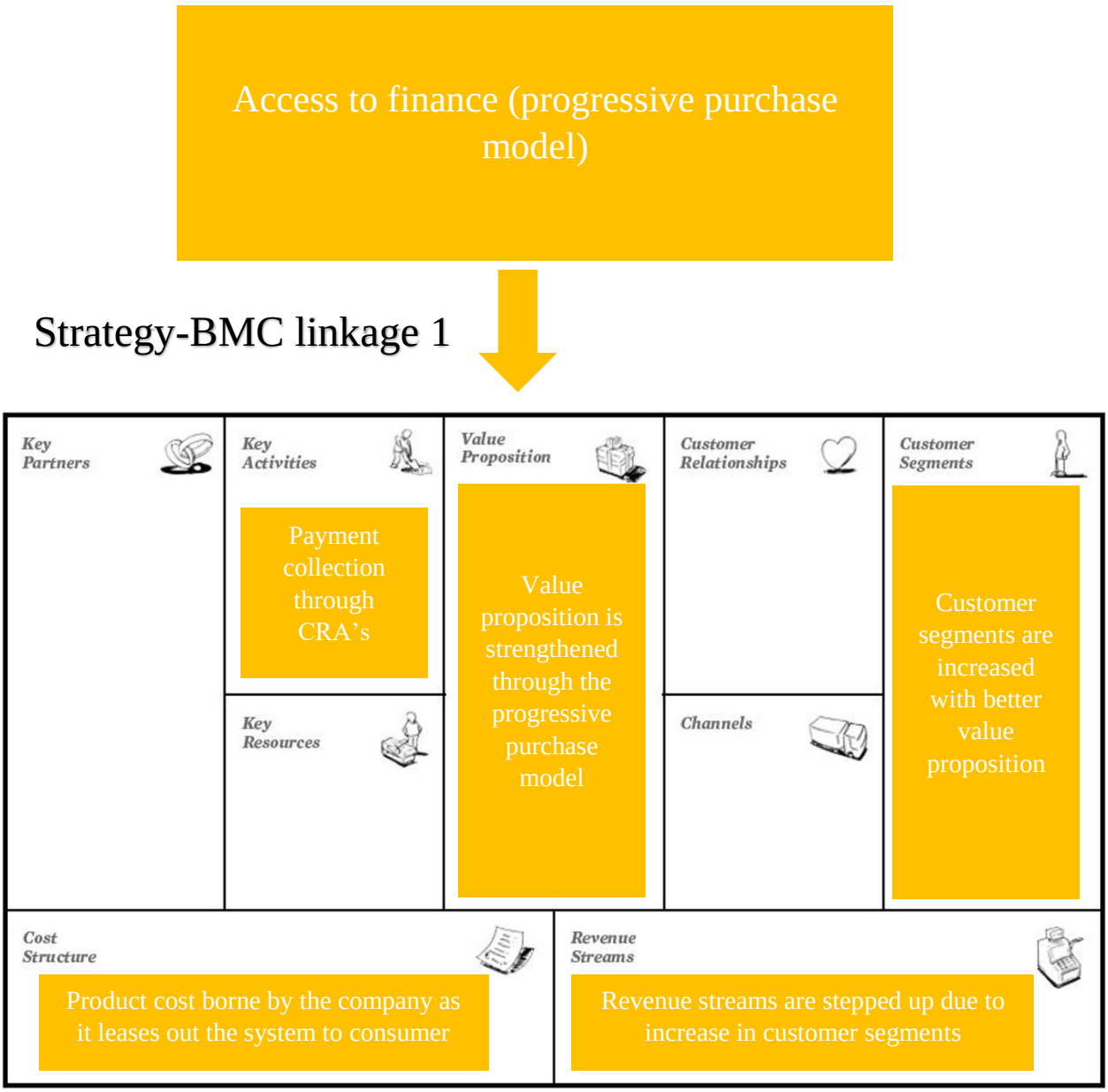

Figure 3-7 Strategy-BMC linkage 1 - Simpa Networks

The access to finance strategy for consumers is implemented in the form of a progressive purchase model. The company leases out the product to the consumer on a pay-as-you-go model and consumer pays back in the form of monthly recharges until complete ownership. This affects the ***cost structure*** of the company as the company has to initially make an investment in the product themselves. This way, the company positions itself as a financing and a technology company strengthening its ***value proposition***. The ***key activities*** of the company increase as the payment collection has to be done through its own team. With this strategy, the ***consumer segments*** increase as they now have access to purchase and henceforth the ***revenues*** are also increased. There are no ***key partners*** involved in this strategy and has no implication on the ***key resources***. ***Customer relationships*** are not directly built with this strategy but rather built with a strategy followed by this which is the service and maintenance strategy.

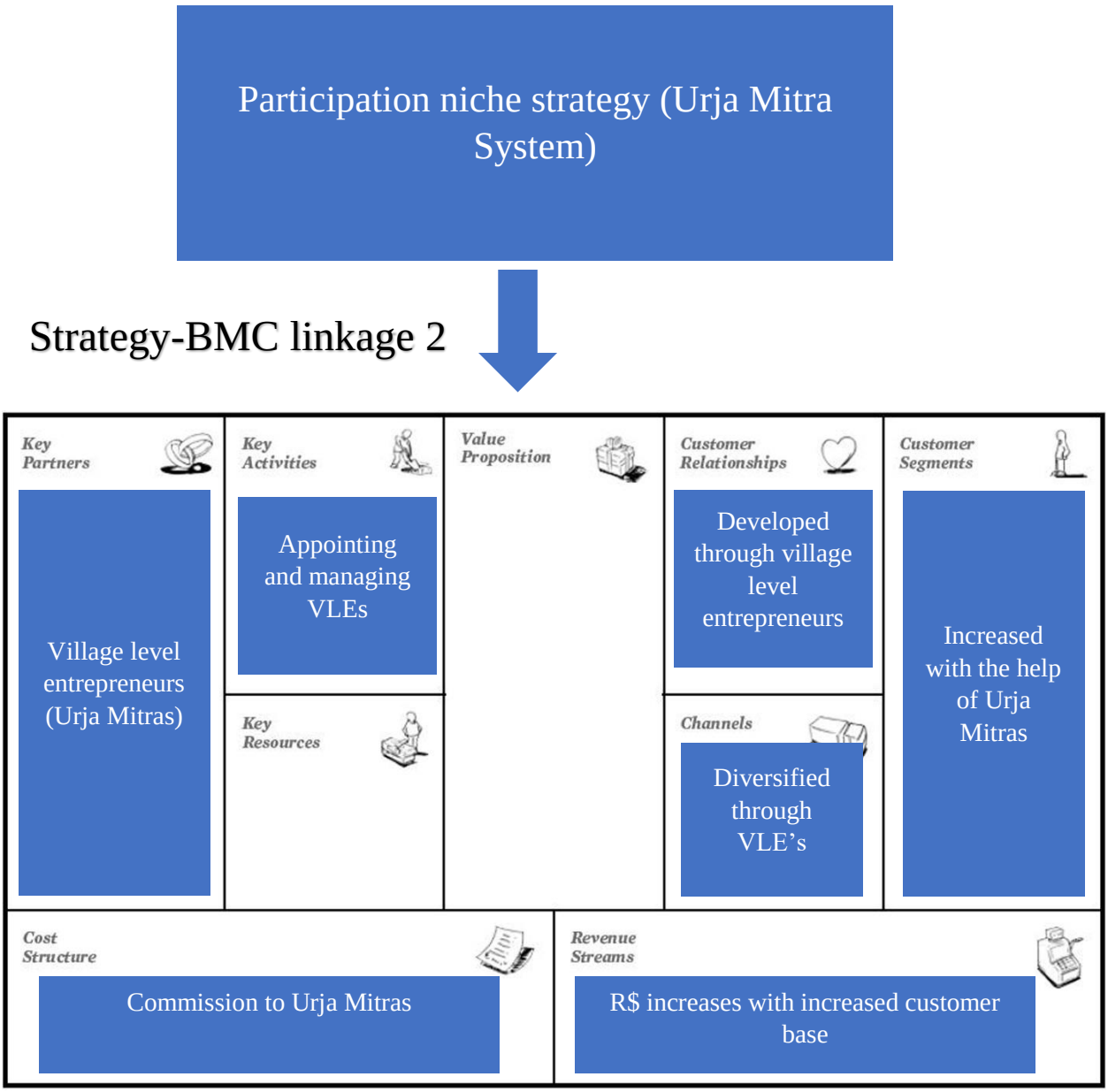

Figure 3-8 Strategy-BMC linkage 2 - Simpa Networks

The participation niche strategy or the "Urja Mitra" system is an important part of their business operations. This strategy helps in improving the ***customer reach*** as the Urja Mitras or Village Level Entrepreneurs act as ambassadors of the company and reach out to the end consumer. They play a key role in building ***customer relationships*** as they meet people on a daily basis. The distributing ***channels*** of the company are diversified with the help of the urja mitras. These VLE's are built in the form of ***key partners*** to the company and they work on commission basis which affects the ***cost structure*** in a minor way. The ***key activities*** are also added up as the company has to appoint and manage village level entrepreneurs. The stakeholders involved are external to the focal company and hence attributed as key partners and not ***key resources***. These partners help in delivering the **value *proposition*** but does not affect the nature of the VP delivered.

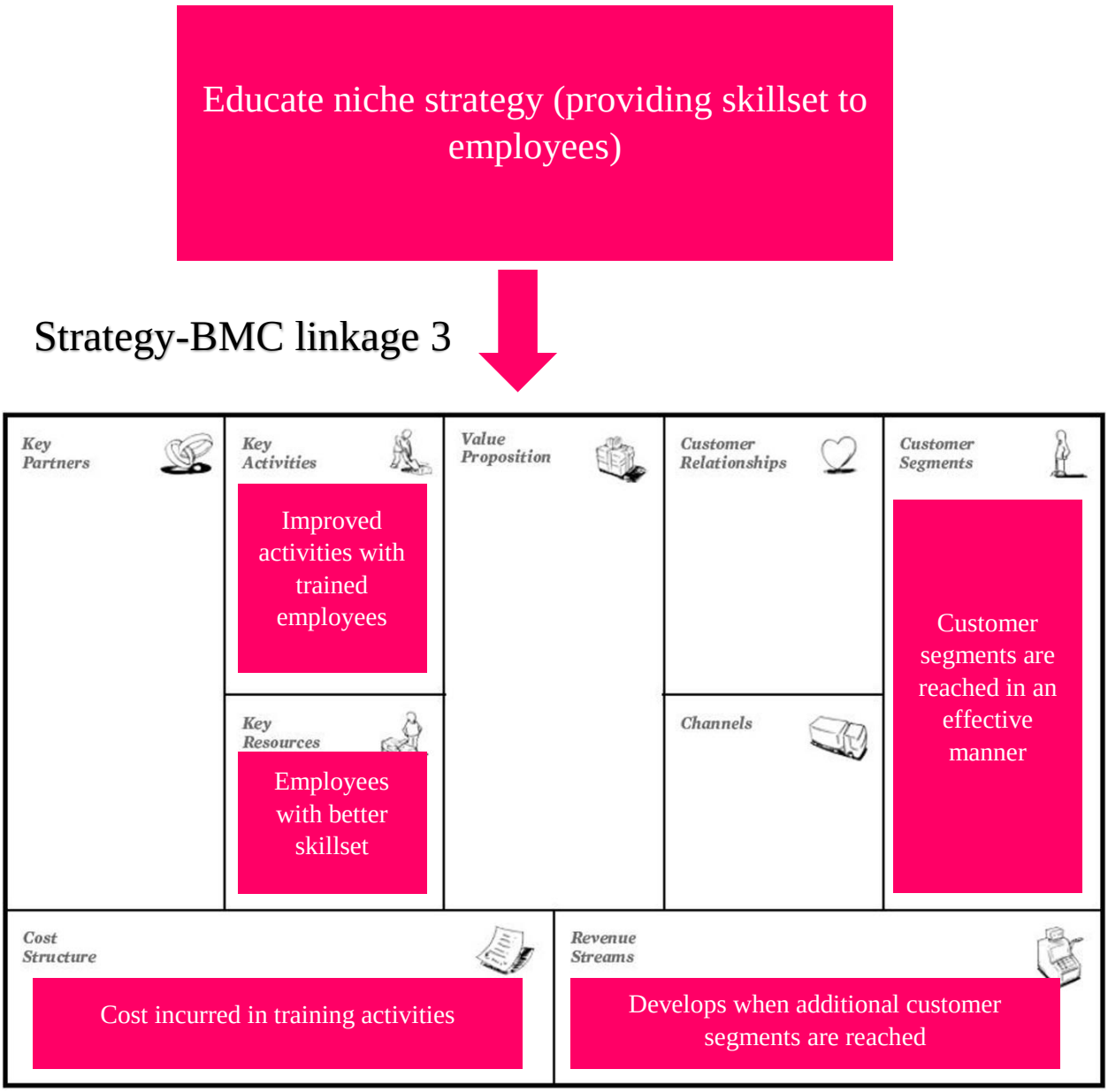

Figure 3-9 Strategy-BMC linkage 3 - Simpa Networks

The educate niche strategy to provide relevant skillset to the employees is relevant for better operations on the field. The operations are selling, servicing & maintaining, and managing "urja mitras" or village level entrepreneurs which are the ***key activities*** of Simpa. This strategy is implemented in the form of a Training Certificate Program held in the company headquarters. The ***key resources*** of the company who are the employees in this case develop themselves with better skillsets due to the training provided by the company under educate niche strategy. There is some cost involved in conducting the training activities but is not a major part of the ***cost***. There are no ***key partners*** addressed for this strategy, however, key partners can be involved to conduct the training programs separately. With better key activities, ***customer segments*** are reached in an effective manner. This strategy does not change the nature of the ***value proposition*** and the distributing ***channels*** as the strategy is intended only towards building skilled workforce. Also, the customer focused element which is ***customer relationship*** is not affected as this is an internal strategy of the company. This has an indirect effect on the revenue streams which tend to develop when customer segments are increased.

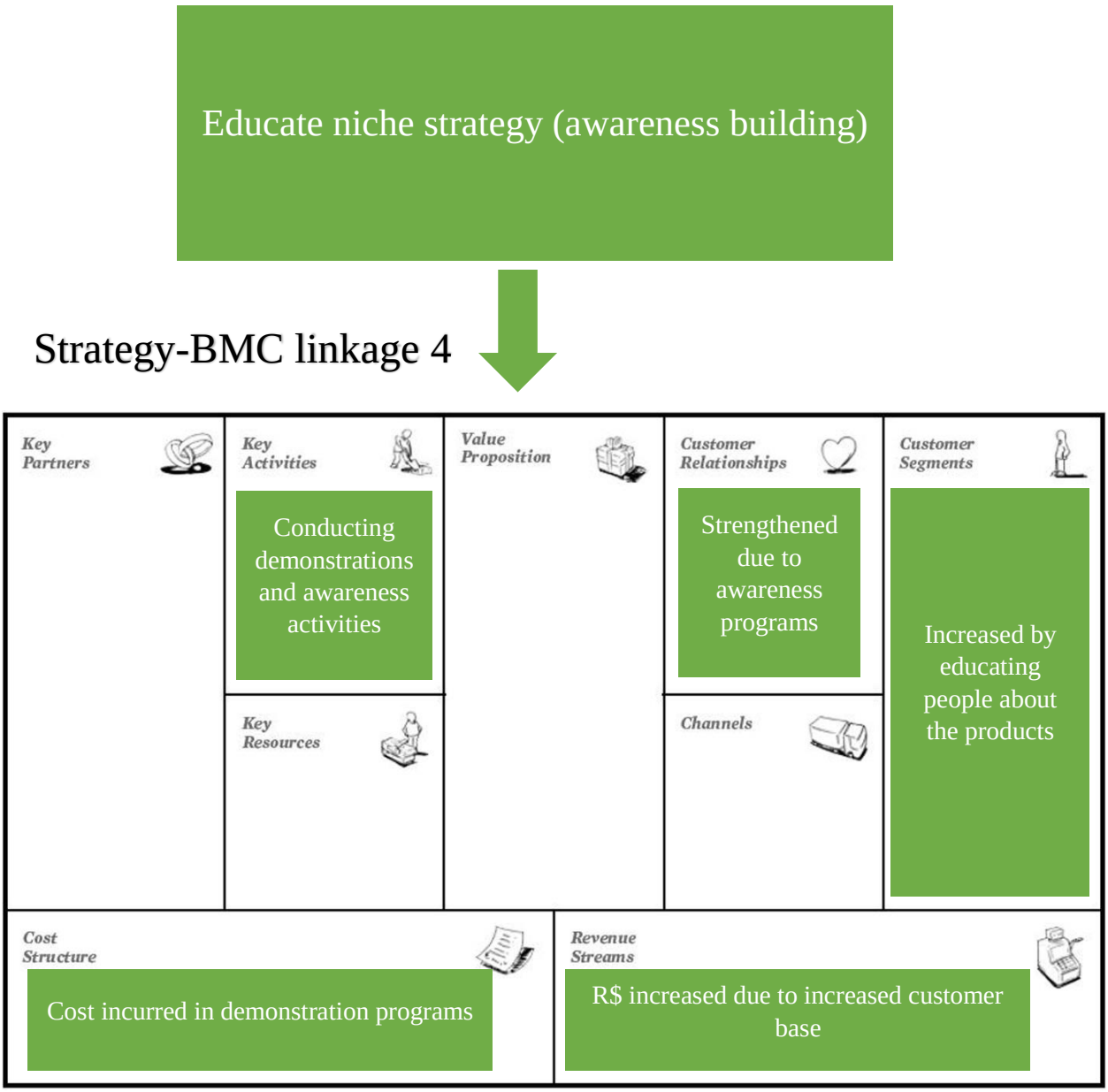

Figure 3-10 Strategy-BMC linkage 4 - Simpa Networks

The educate niche strategy is implemented in another form which is to impart knowledge and create awareness among the end consumers. The ***customer relationships*** are developed during interaction with the company executives in demonstration and awareness activities. These awareness activities help in attracting consumers as they are educated about the products and its benefits. However, the awareness activities involve certain costs which the company has to invest which affects the ***cost structure***. The result of this strategy is increased ***customer base*** and ***revenue streams***. The ***key activities*** here are conducting demonstrations and awareness programs. No key partners are involved here in the demonstration activities, however, there can be some key partners (such as NGOs and community workers) which help in implementing this strategy.

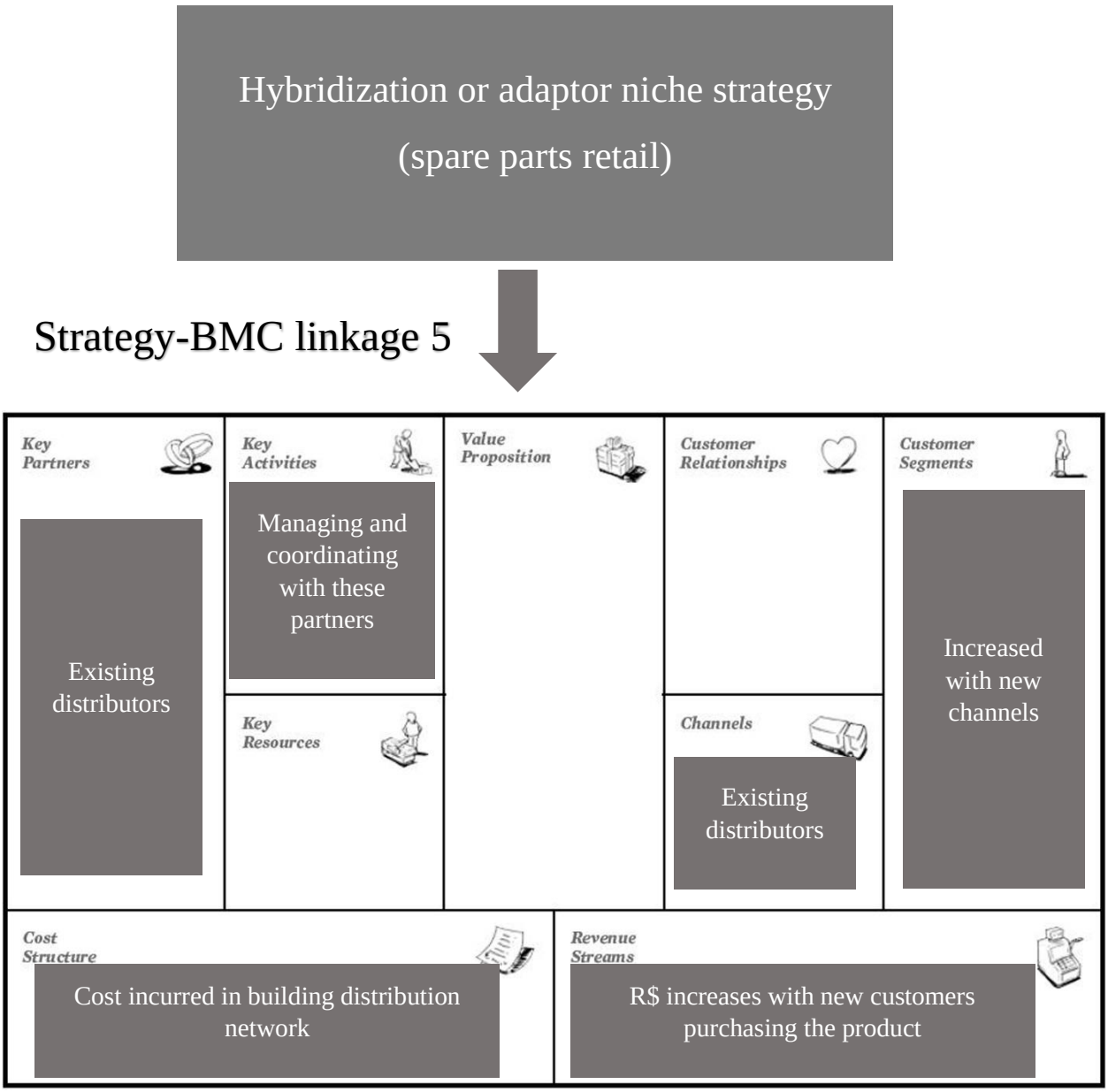

Figure 3-11 Strategy-BMC linkage 5 - Simpa Networks

The hybridization or adaptor niche strategy is described for finding distributors who have an existing ***customer base***. This is vital in reaching out to the end consumers through existing distributors. These existing distributors extends the arms of distribution network by increasing the ***channels*** to reach the customer. The existing distributors are the ***key partners*** of the company. The ***revenue streams*** are stepped up with new customers being added to the system. However, this comes with a certain **cost** incurred in building the distribution network. To manage and coordinate with these partners is an important ***key activity*** for the focal company. This strategy is focused on increasing the distribution network and increasing the customer segments and hence does not affect the internal factors such as key resources. The ***customer relationships*** are not directly built with the company as key partners in the form of distributors are involved in between. The ***value proposition*** remains the same as the existing distributing help in delivering the VP through distribution of products.

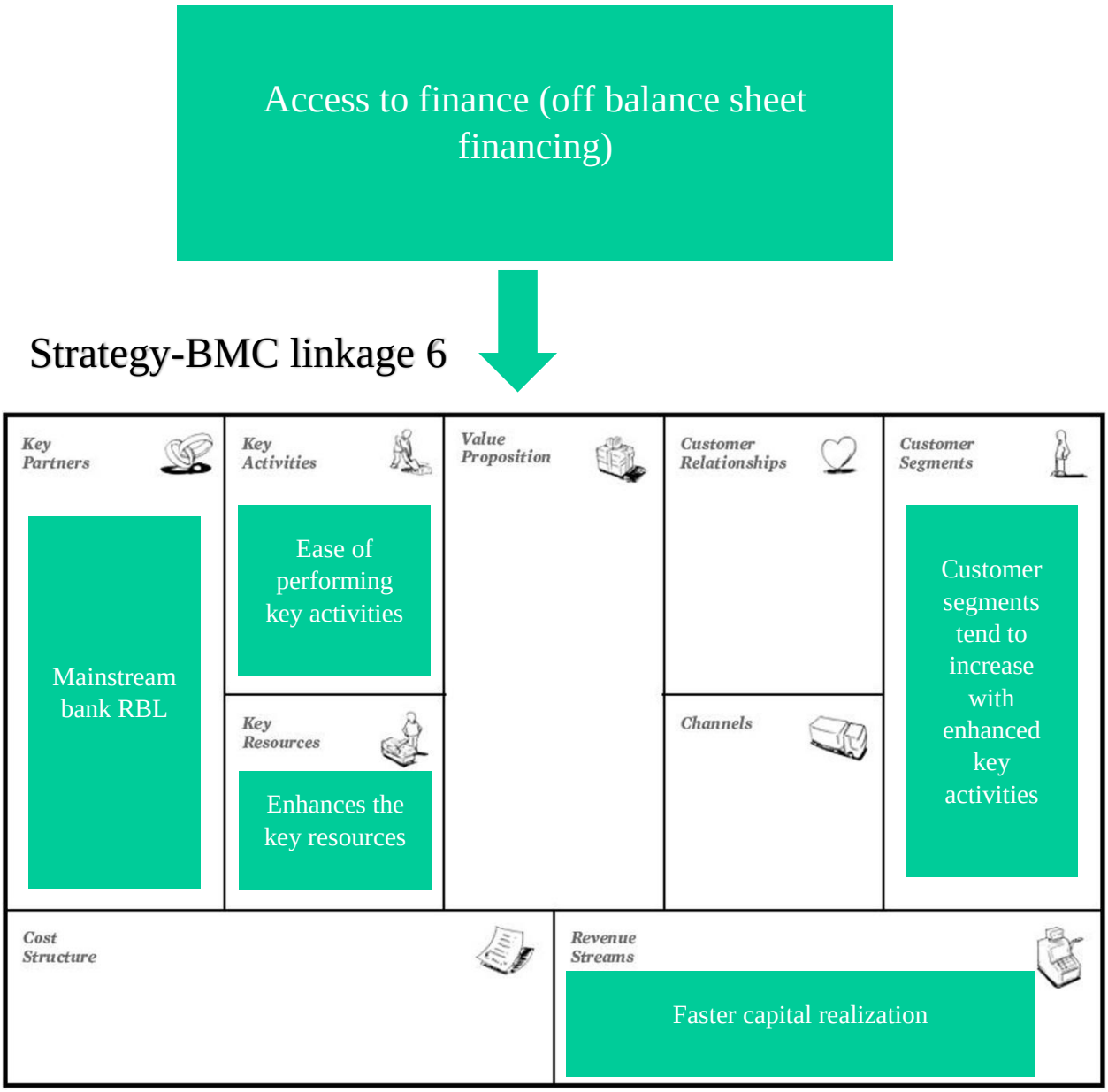

Figure 3-12 Strategy-BMC linkage 6 - Simpa Networks

The access to finance strategy in the form of off-balance sheet financing is relevant from the company's perspective. Simpa has partnered with RBL Bank who pays the upfront cost directly to the company in an event of sale of the product. This mechanism is called off-balance sheet financing. This off-balance sheet financing instrument is added as a ***key resource*** for Simpa Networks. The cost is recovered by the company from the consumer and paid back to the bank in a span of agreed upon period. This results in faster capital realization which has a positive impact on ***revenue streams***. RBL Bank acts as a ***key partner*** for Simpa Networks under this strategy. The key activities are also performed with ease as the company builds its financing resources. This is an internal strategy for the company hence its does not affect the customer oriented factors such as ***customer relationship*** and ***channels*** for distribution**.** With the ease in key activities such as marketing & operations, this strategy helps in building its ***consumer segments.***

3.2. Rural Spark

"The only way to get true insights in how to transform society, is by actually doing it" ~ Rural Spark

Table 3-6 Company Profile

Founders	**Evan Mertens, Harmen van Heist, Marcel van Heist**
Address (India)	RURAL SPARK DELHI E-158, Greater Kailash 3 110048 - Delhi India **Tel: +91 11 65091330**
Address (The Netherlands)	Burg. Loeffplein 70 B/C (kamernummer MB1) 5211 RX 's-Hertogenbosch The Netherlands **Tel: +31 6 52 04 59 73**
Contact	rob@ruralspark.com
Contact Persons	Rob de Jeu (Business Manager)
Website	http://ruralspark.com/

3.2.1. Introduction

Rural Spark is a Dutch energy startup with its operations in the rural parts of India in the states of Uttar Pradesh & Bihar. The company offers innovative products which are user centric i.e. specially designed according to the usability of the end consumers. The products include Rural Spark Energy Kit and a Rural Spark lamp as shown in *figure 3-13 & 3-14* respectively. The Rural Spark concept is based on creating entrepreneurs in the villages who generate, use and sell energy to their fellow villagers. The entrepreneurs are called Local Energy Suppliers. The surplus energy is traded among these local energy suppliers and this way, the supply and demand are met efficiently. The company delivers a future-proof solution with inclusive development for all, leapfrogging the central grid and existing solutions. The company has been awarded and nominated in several business plan competitions in the Netherlands and recognized by the Indian and the Dutch media. They have a small team of 16 out of which 6 run the Delhi office.

3.2.2. Product range

The product range of Rural Spark includes two major products which are the *Rural Spark Energy Kit* and *Rural Spark Lamp*. The energy kit consists of a rural spark router, an energy source (PV panel), storage (modular cubes) and applications include fan, mobile charging point, and bulbs. Recently, a new product has been launched by Rural Spark in the name of Rural Spark Energy & TV kit which allows the rural populace to entertain themselves by watching TV.

Figure 3-13 Rural Spark Energy Kit (RuralSpark n.d.)

Figure 3-14 Rural Spark Lamp (RuralSpark n.d.)

3.2.3. Service & Retail platform

The service and retail platform is an online tool to manage the customer accounts, pre-paid payments and marketing campaigns. This platform works together with the Rural Spark energy router and the existing infrastructure of distributing companies.

3.2.4. Value chain

The value chain of the company includes premium resellers, local energy suppliers and fellow villagers. The energy kits are sold to premium resellers who have an established distribution network. The premium resellers further sell the kits to local energy suppliers who buy the kits on monthly installments which are managed through the Rural Spark service platform. The premium resellers take a margin on the product sold and the local energy suppliers make profit from the products rented to their fellow villagers. The company's value chain is explained in detail in *figure 3-15*

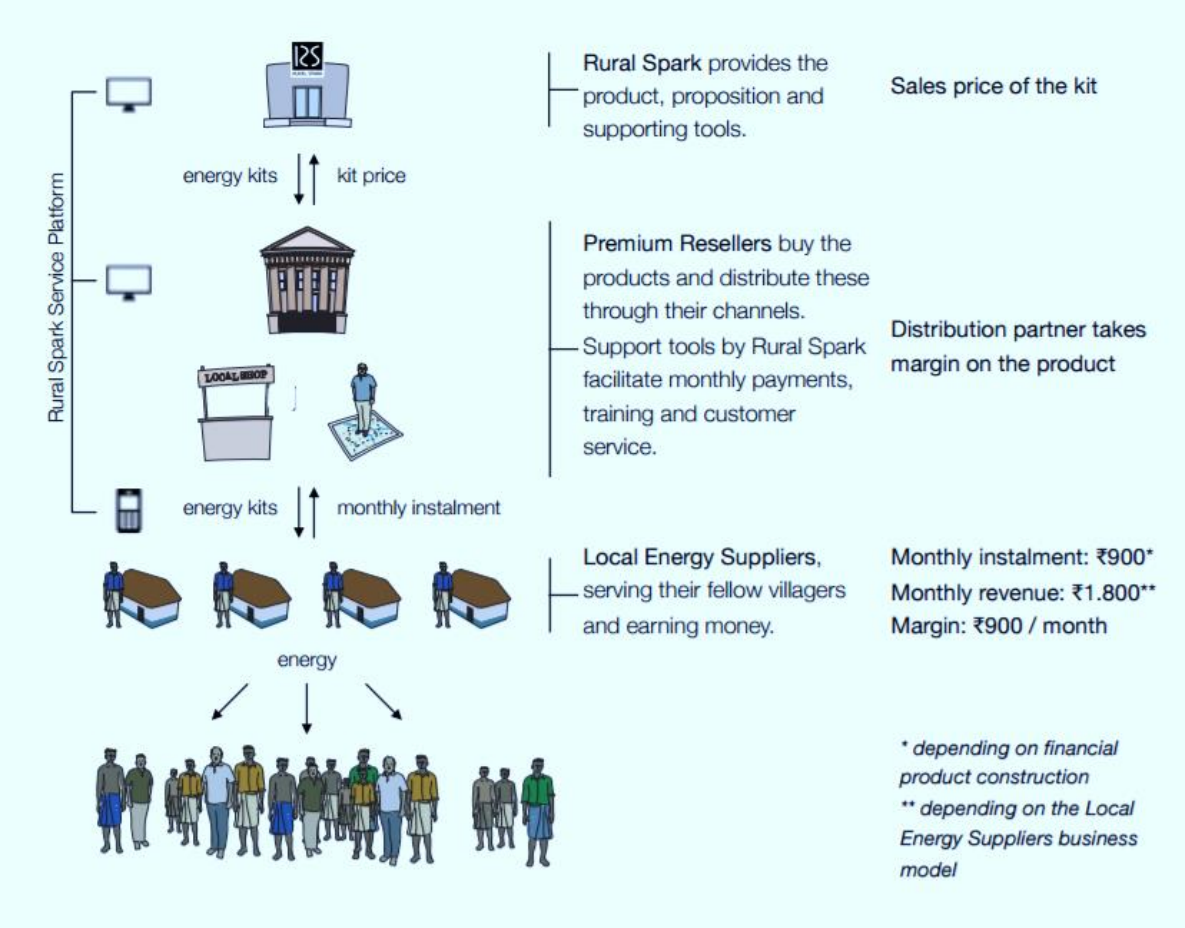

Figure 3-15 Rural Spark value chain (Source: (RuralSpark n.d.)*)*

3.2.5. Open and closed questions to the Rural Spark Team

Table 3-7 Open and closed questions to the Rural Spark team (RuralSpark 2017)

Questions		Quotes
Interviewees		Rural Spark Team
Open questions on barriers	Partnerships	Getting the partnerships done is taking long
	To introduce the concept	Challenge is to explain them the proposition, the new concept, the new model, the second is making them understand the finances behind it
	Awareness	That's also a big challenge because they have perceptions related to the Chinese products.
Closed questions on barriers	Knowledge of technology	Not really an issue
	Natural resources and skilled personnel	Not really an issue
	New high-tech product (cost & quality)	Pricing is a big barrier
	Socio-cultural aspects	Acceptability and openness to a new product

	Macroeconomic aspects	Demonetization has affected payment collection
	Accidents or events	No such issue
	Affordability	Big challenge
	Infrastructure	Yes
	Political	we have not yet faced any political issue
	Stakeholder involvement	It is important, not an issue, we have to put in efforts to convince
	Business knowledge	It is not a challenge, we are a LEAN company
	Institutional aspects (laws, rules & standards)	Not that I can think of, maybe the grid coming up
	Suppliers (manufacturers and vendors of raw material, spare parts)	Delay could be a minor challenge
	Financial	Working capital in the Indian market is kind of challenging. Without that we cannot survive. Financial resources for the end customer is very important as affordability is an issue
Open questions to strategies	Finding partners	"We are focusing on limited number of people who have a very good reach and they can really help us attain the scalability and reach we are looking at."
	Product strategy	"This is a long-term vision of having smart grid in India. We have a separate wing for our research and products because the idea is to make the smart grid vision concrete that's why we are collaborating with TERI, TU Eindhoven. You can also say we have a product strategy in terms of giving a high-quality product. High quality and high user-friendly product"
	Pilot projects	"Our focus is on joint pilots with other distribution companies"
Closed questions to strategies	Access to finance	"That's a strategy we are working on it. We have an established line of action plan we have in place. It is fairly simple"
	Educate niche strategy	"Field executives who are there in our pilot area. They are actually very well connected to the villagers because they also belong to self-help groups. They are women from the Federation itself. They have very good connections and linkages. You know how often these self-help groups meet. That provides a very good space to educate people."

	Geographic niche strategy	"We are looking for different types of partners in different geographies and trying to do over the whole base of pyramid segment"
Closed questions to BMC	Key partners	TERI, TU e, suppliers, premium resellers, manufacturers, funding organization, BASIX (pilot in Bihar), PRE (power research electronics) big technology partner in the Netherlands
	Key activities	Design, Testing, selling, distribution, operations, after sales service, customer service, logistics, promotions
	Value proposition	To sell the product to the distribution partner, it makes electricity available through VLE and top of it, he can earn from it by renting it to fellow villagers
	Customer Relationship	We want to be in touch with the end user for 15-18 months to get the feedback and we also want to know what else can we do for them. Customer service number, share information through SMS, online service platform, own field staff only for the pilot project.
	Customer Segments	Our direct customers are our distributing partners
	Revenue Streams	from distribution companies
	Cost Structure	Salaries, production

3.2.6. Barrier results

The barrier results are divided into influencing and core factors which are discussed in *table 3-8*. Getting the partnerships done is a big challenge for Rural Spark as their key value proposition revolves around their partners also called as "Premium Resellers". Rural Spark is a young organization and not well established. It is taking them a long time to find suitable partners. To make their product available through an established channel is the most important challenge faced by them. Another significant challenge is the lack of awareness among people and to explain the value proposition to potential customers. Explaining the functionality of the product to the customer and the distributing partner is a challenging task for Rural Spark. Pricing of the kit is a big barrier for the company as the affordability among the rural population is low. Rural Spark is primarily a technology company and has designed the product keeping in mind the future scenarios and needs. The text mentioned in green does not indicate any barrier.

Table 3-8 Barriers (influencing and core) faced by Rural Spark

Indirect (Influencing) factors	Direct (Core) factors
Knowledge of technology Not really an issue	***New high-tech product (cost & quality)*** Pricing is a big barrier
Knowledge of application	***Production system***
Natural resources and skilled personnel Not really an issue	***Complimentary products & services (distribution & use)*** Finding partners as distributors

Socio-cultural aspects Acceptability and openness to a new product	***Suppliers (manufacturers and vendors of raw material, spare parts)*** Delay could be a minor challenge
Macroeconomic aspects Demonetization has affected payment collection	***Customers***
Accidents or events No such issue	***Institutional aspects (laws, rules & standards)*** Not that I can think of, maybe the grid coming up
Affordability Big challenge	***Consumer awareness & risk perception*** Is a big challenge, challenge is to explain them the proposition, the new concept, the model and to explain the finances behind it, perception related to Chinese products
Infrastructure Yes	***Financial*** Working capital in the Indian market is kind of challenging. Without that we cannot survive. Financial resources for the end customer is very important as affordability is an issue
Environmental	
Political we have not yet faced any political issue	
Stakeholder involvement It is important, not an issue, we have to put in efforts to convince	
Business knowledge It is not a challenge, we are a LEAN company	

3.2.7. Strategies

Rural Spark is working on several strategies to develop their business. Six major strategies have been identified during the interview and are discussed under *table 3-9*. These strategies are finding partners under the hybridization or adaptor niche strategy, product strategy which includes R&D, access to finance, educate niche strategy for awareness building, pilot project and geographic niche strategy to increase the customer reach.

Table 3-9 Strategies by Rural Spark

New/ Original Strategy	Adapted/new definition
Finding partners (hybridization or adaptor niche strategy)	"We are focusing on limited number of people who have a very good reach and they can really help us attain the scalability and reach we are looking at."
Product strategy (Research & development)	"This is a long-term vision of having smart grid in India. We have a separate wing for our research and products because the idea is to make the smart grid vision concrete that's why we are collaborating with TERI, TU Eindhoven. You can also say we have a product strategy in terms of giving a high-quality product. High quality and high user-friendly product"
Access to finance	"That's a strategy we are working on it. We have an established line of action plan we have in place. It is fairly simple"

Educate niche strategy (awareness building)	"Field executives who are there in our pilot area. They are actually very well connected to the villagers because they also belong to self-help groups. They are women from the Federation itself. They have very good connections and linkages. You know how often these self-help groups meet. That provides a very good space to educate people."
Pilot projects	"Our focus is on joint pilots with other distribution companies"
Geographic niche strategy	"We are definitely very open to it. We are looking for different types of partners in different geographies and trying to do over the whole base of pyramid segment."

3.2.8. Elements of Business Model Canvas

The nine key elements of BMC are discussed in relation to Rural Spark in *table 3-10.* The *key partners* of Rural Spark include TERI (The Energy & Resources Institute), Eindhoven University, PRE (Power Research Electronics), premium resellers, suppliers, and manufacturers. The *key activities* include design, testing, selling, distribution, operations, after sales service, customer service, logistics and promotional activities. The *value proposition* is to sell the product to a distribution partner also called as the premium reseller and then electricity is further made available through the local energy supplier who are also the village level entrepreneurs so that they can sell energy to their fellow villagers and earn some money. The *customer relationships* are built through a customer service number which is provided to the customers in case of any technical difficulty, and the information is supplied through SMS and the online service platform. In pilot projects, this is done by the field staff. The direct customers are the premium resellers who sell the products to village level entrepreneurs (or the local energy suppliers) who further serve the fellow villagers. The *channel* to serve the end customer is via distributing partners. The *key resources* of the company are their product and employees. The major costs are incurred in the product manufacturing and salaries whereas revenues come from the distributing partners.

Table 3-10 Elements of BMC (Rural Spark)

<table>
<tr><td rowspan="2">Key Partners
TERI, TU e, suppliers, premium resellers, manufacturers, funding organization, BASIX (pilot in Bihar), PRE (Power Research Electronics) in the Netherlands</td><td>Key Activities
Design, Testing, selling, distribution, operations, after sales service, customer service, logistics, promotions</td><td rowspan="2">Value Proposition
To sell the product to the distribution partner, it makes electricity available through VLE and top of it, he can earn from it by renting it to fellow villagers</td><td>Customer Relationships
Customer service number, information through SMS, online service platform, own field staff for the pilot project</td><td rowspan="2">Customer Segments
distributors</td></tr>
<tr><td>Key Resources
Employees
Product</td><td>Channels
Through distributing partners</td></tr>
<tr><td colspan="3">Cost Structure
Salaries, production</td><td colspan="2">Revenue Streams
from distribution companies</td></tr>
</table>

3.2.9. Link between barriers, strategies and BMC elements

In this section, the relationship between barriers, strategies and BMC elements is studied. *Figure 3-16* graphically describes the relationship between barriers, strategies and BMC elements. The individual barriers are linked to the respective strategies as seen in *figure 3-17*. The effect of barriers on BMC elements is described briefly in *section 3.2.10*. The effect of strategies is explicitly defined in strategy-BMC linkages developed for Rural Spark in *section 3.2.11*. These linkages bring clarity to the implications of the strategies on the business model canvas. The affected elements of BMC are clearly indicated in the strategy-BMC linkage *figures (3-19 to 3-24)*. These linkages and implications are analyzed by the author based on the case study interviews.

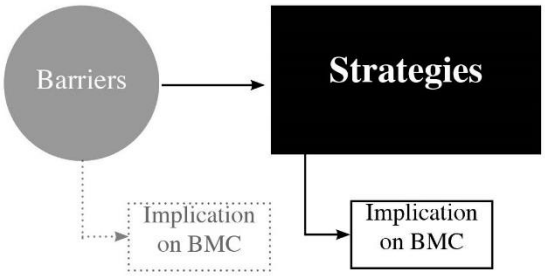

Figure 3-16 Linkage between barriers, strategies & BMC

In *figure 3-17*, the key barriers are linked to the respective strategies and are color coordinated. The difficulty faced in getting the partnerships done is linked to the hybridization or adaptor niche strategy (finding partners) where the company is looking to tie up with existing distributors who have a good customer reach. Low consumer awareness is linked to the educate niche strategy which is about awareness building among the end consumers. The working capital is obtained via established action plan through the access to finance strategy.

Figure 3-17 Barrier-strategy linkage for Rural Spark

3.2.10. Implication of barriers on the business model canvas

Lack of knowledge of technology is not really an issue for Rural Spark as it is a product focused company and does not seem to hamper their business model. Affordability and high pricing is a

challenge for the company which affects the targeted customer segments and hence the revenue streams. Finding distributing partners is a barrier for the company which affects their key value proposition as the direct customers are the distributing partners or premium resellers. Lack of working capital impacts the company's key activities which are blocked due to this barrier.

3.2.11. Implication of employing strategies on the business model canvas

The implications of each strategy on the business model canvas is discussed in this section in detail. Six main strategies are discussed as mentioned in *figure 3-18*.

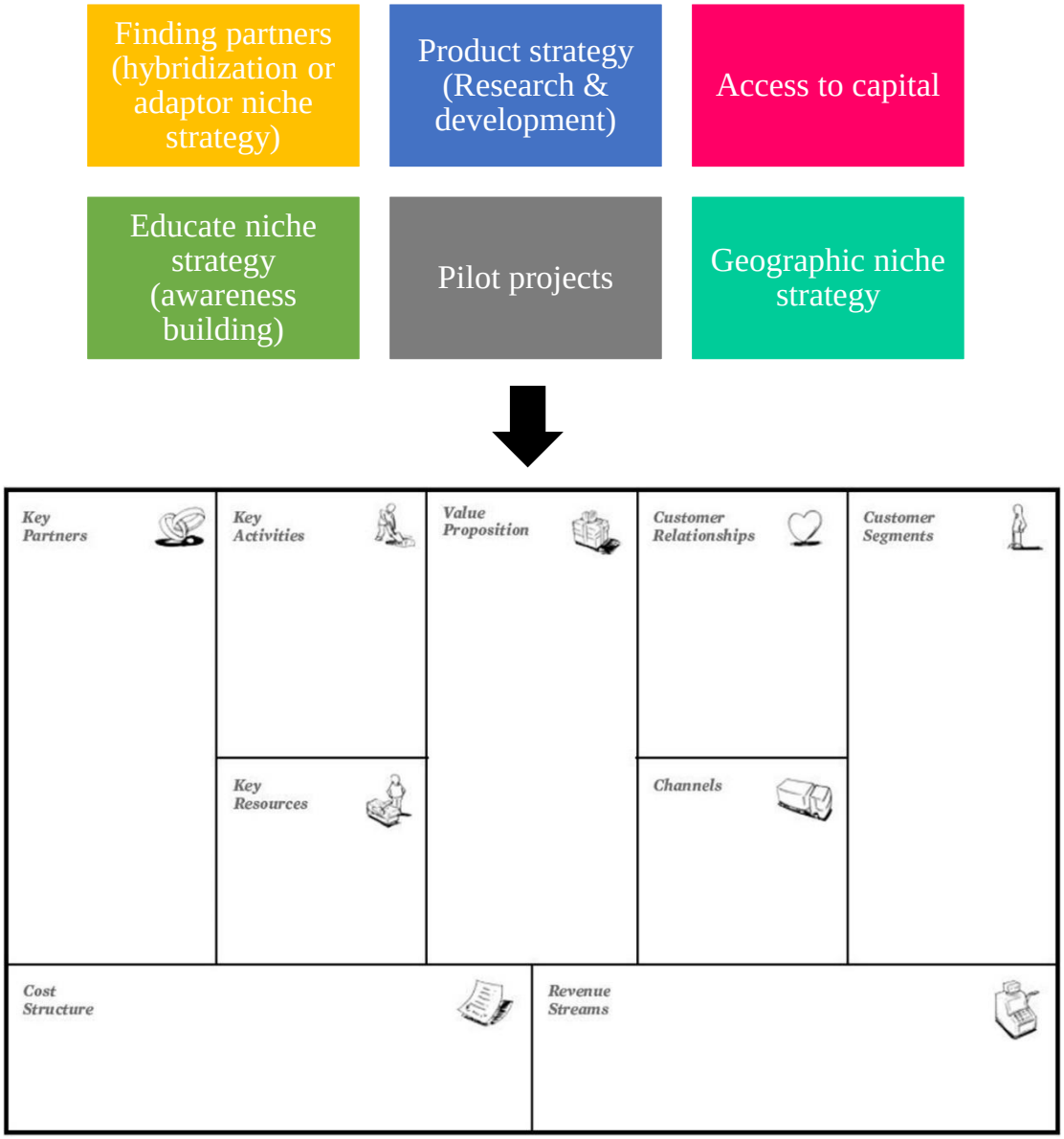

Figure 3-18 Effect of six strategies by Rural Spark on BMC

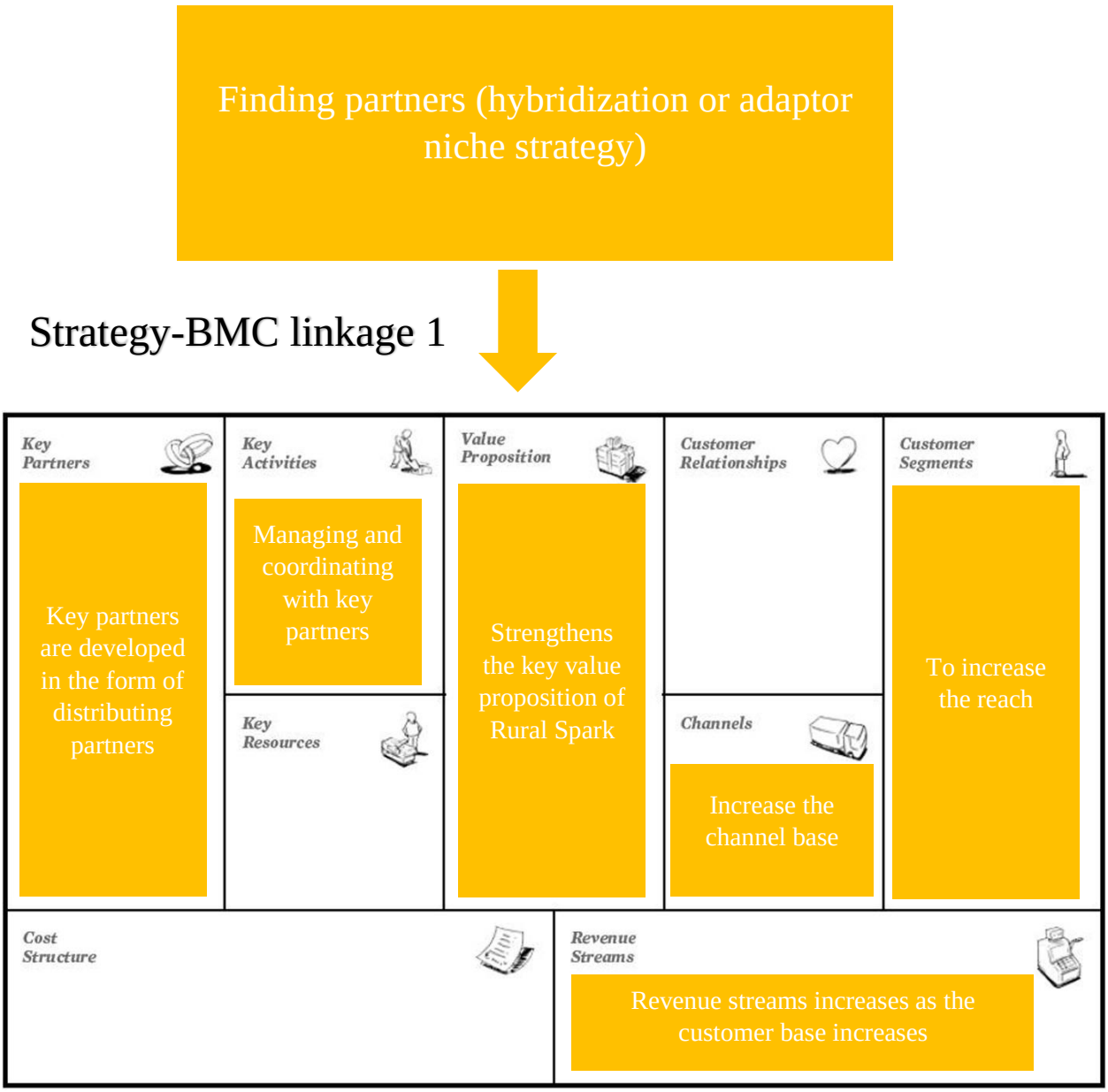

Figure 3-19 Strategy-BMC linkage 1 – Rural Spark

Finding partners in the form of distributing partners or premium resellers is vital for Rural Spark to build their ***value proposition*** as their main target customers are these existing distributors. With these distributors, the ***channels*** increase for the company to reach out to the end consumers. The company nurtures and develops these distributors as ***key partners***. These partners increase the ***customer reach*** thereby increasing the ***revenue streams***. The ***customer relationships*** are not directly built with the company as the key partners or premium resellers are involved in between. Managing and coordinating with these key partners is an important ***key activity*** for the focal company. No ***key resources*** are added to the company as this strategy focuses on ***key partners***.

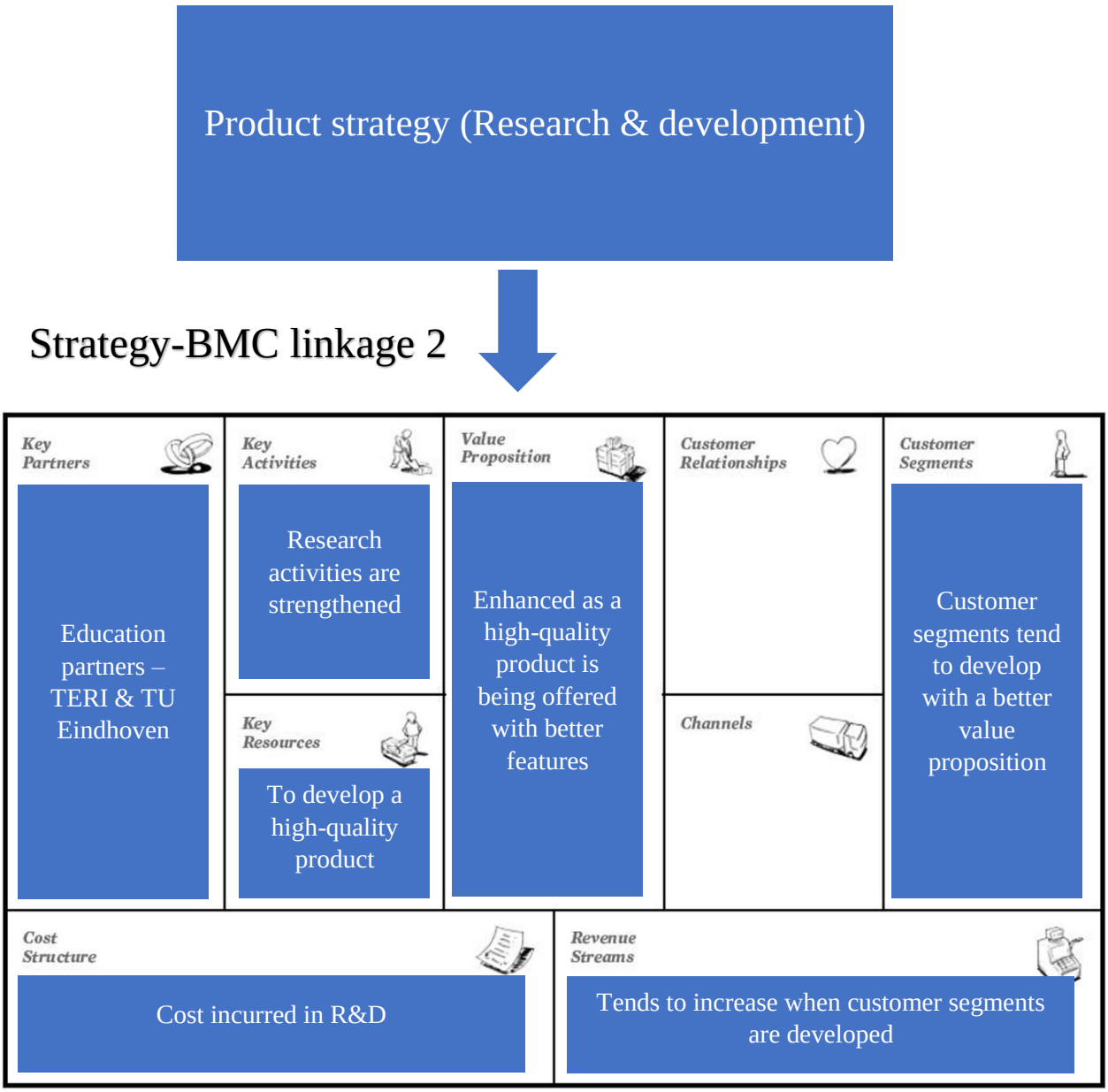

Figure 3-20 Strategy-BMC linkage 2 – Rural Spark

Rural Spark is essentially a product based company where research and development is a core part of their strategy. The aim is to develop a high-quality product in the form of ***key resource*** of a company. The ***key activities*** such as product research is strengthened with this strategy. The **key partners** are developed in the form of education and technology partners (for instance TERI, TU Eindhoven and Power Research Electronics in this case). All of this comes with a cost which is incurred in the research activities affecting the ***cost structure***. In addition to this, the ***value proposition*** is enhanced as a high-quality product is being offered with better features which also starts to develop the ***customer segments***. This strategy becomes a part of demo, experiment and develop niche strategy in the original Ortt *et al.* framework. This is an internal strategy for the focal company hence it does not affect the ***customer relationship*** and ***channels*** for distribution. This has an indirect effect on the revenue streams which tend to develop when customer segments are increased.

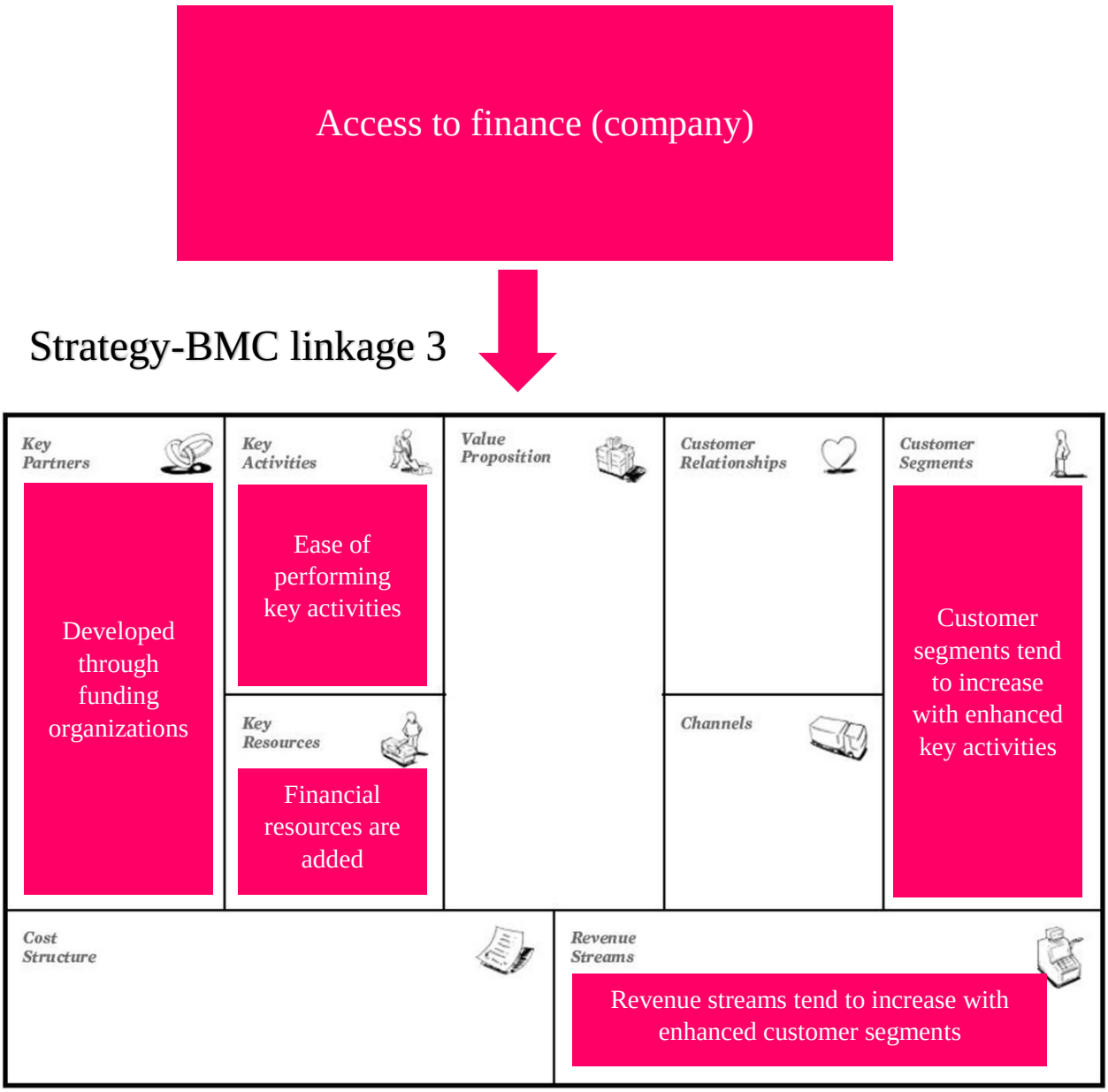

Figure 3-21 Strategy-BMC linkage 3 – Rural Spark

The access to finance for Rural Spark is executed through various funding organizations. The company has an established line of action plan in obtaining the working capital. The funding organizations are developed in the form of ***key partners*** which is an important element of the business model canvas. The ***key activities*** are performed at ease with the availability of working capital. The financial instruments obtained via funding organizations are added to the ***key resources*** element of the business model. This is an internal strategy for the company hence its does not affect the customer oriented factors such as ***customer relationship*** and ***channels*** for distribution**.** With the ease in key activities such as marketing & operations, this strategy helps in building its ***consumer segments. Revenue streams*** tend to increase with enhanced customer segments.

Educate niche strategy (awareness building)

Strategy-BMC linkage 4

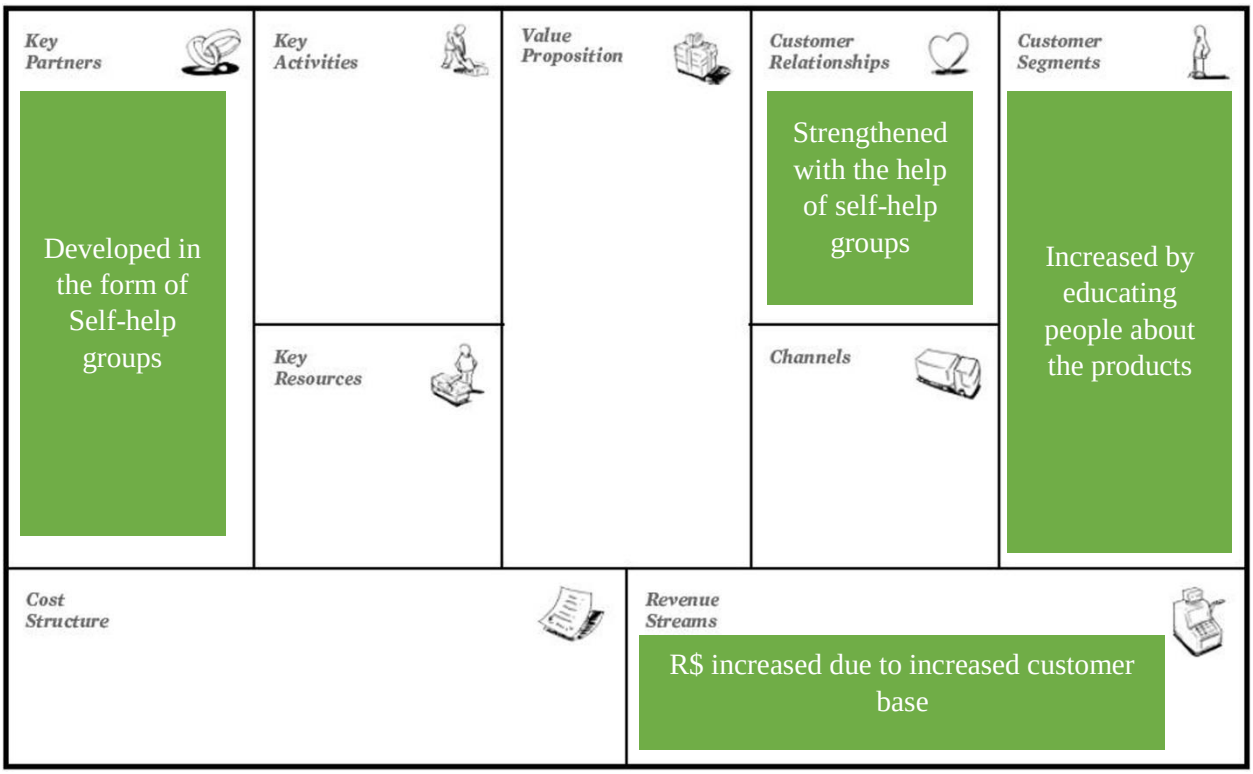

Figure 3-22 Strategy-BMC linkage 4 – Rural Spark

The educate niche strategy in the form of creating awareness among the end consumers is essential in educating and training the customers. The ***customer relationship*** is developed with the help of self-help groups who train these consumers. These self-help groups are developed as ***key partners*** and play an important role in disseminating knowledge to the end customers. This helps in increasing the ***customer segments*** and hence the ***revenue streams***. These partners help in delivering the ***value proposition*** but does not affect the nature of the VP delivered. This strategy does not have an implication on the ***channels*** as no distribution is involved in this strategy.

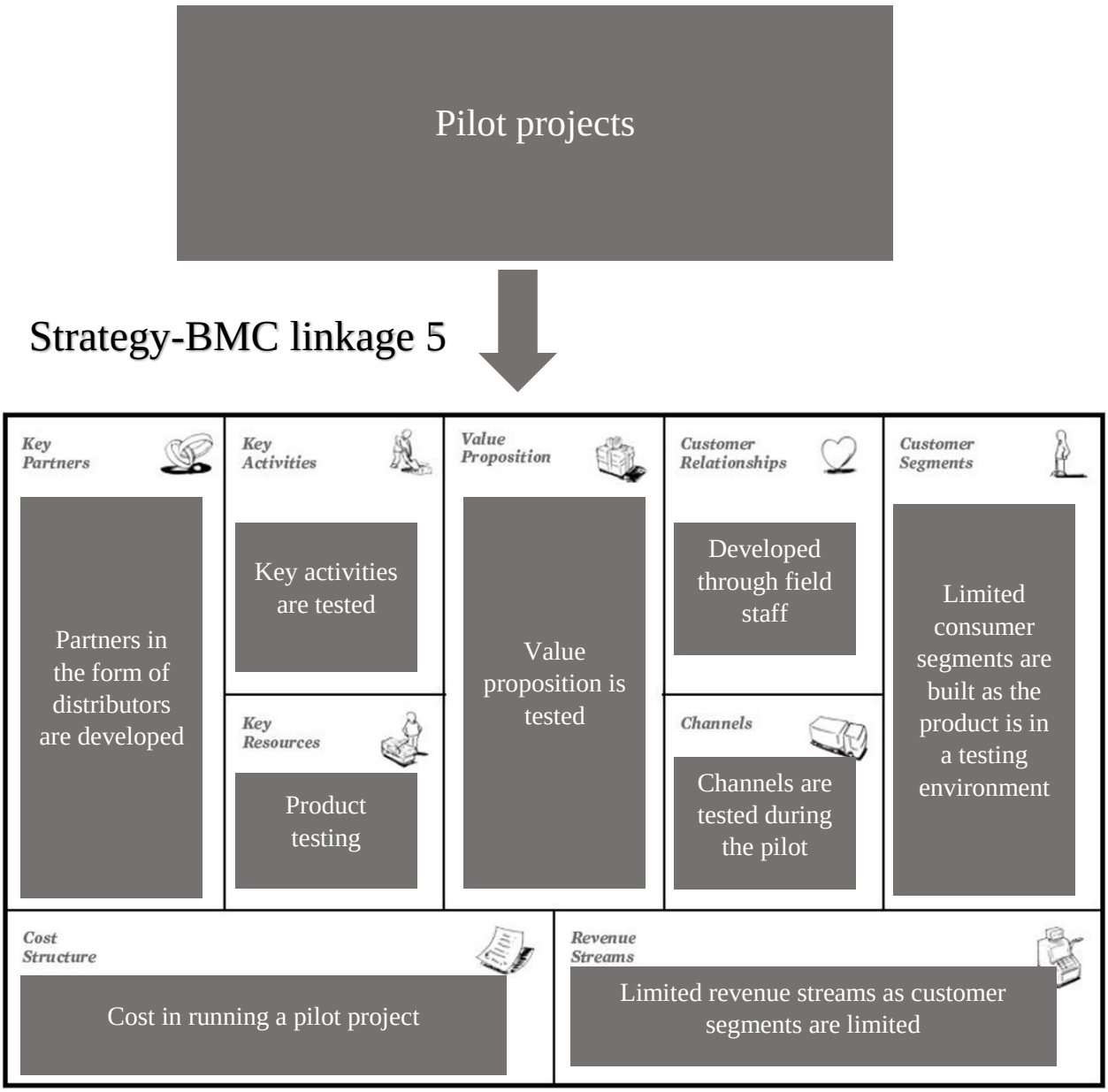

Figure 3-23 Strategy-BMC linkage 5 – Rural Spark

Running a pilot project is like running complete business but on a small scale. The various pilot projects are executed to test the ***value proposition***, ***channels and key activities*** of the focal company. These distributing partners in the form of channels are relevant as they are nurtured in the form of ***key partners***. The product which is a ***key resource*** of the company is also tested in this demonstration environment. ***Customer relationship*** is built through field staff of the company in the pilot projects. ***Customer segments*** are limited which results in limited ***revenue streams*** as the product is in a testing environment. The ***cost structure*** is affected as there are certain costs in running the entire pilot. The strategy becomes a part of demo, experiment and develop niche strategy along with the product strategy.

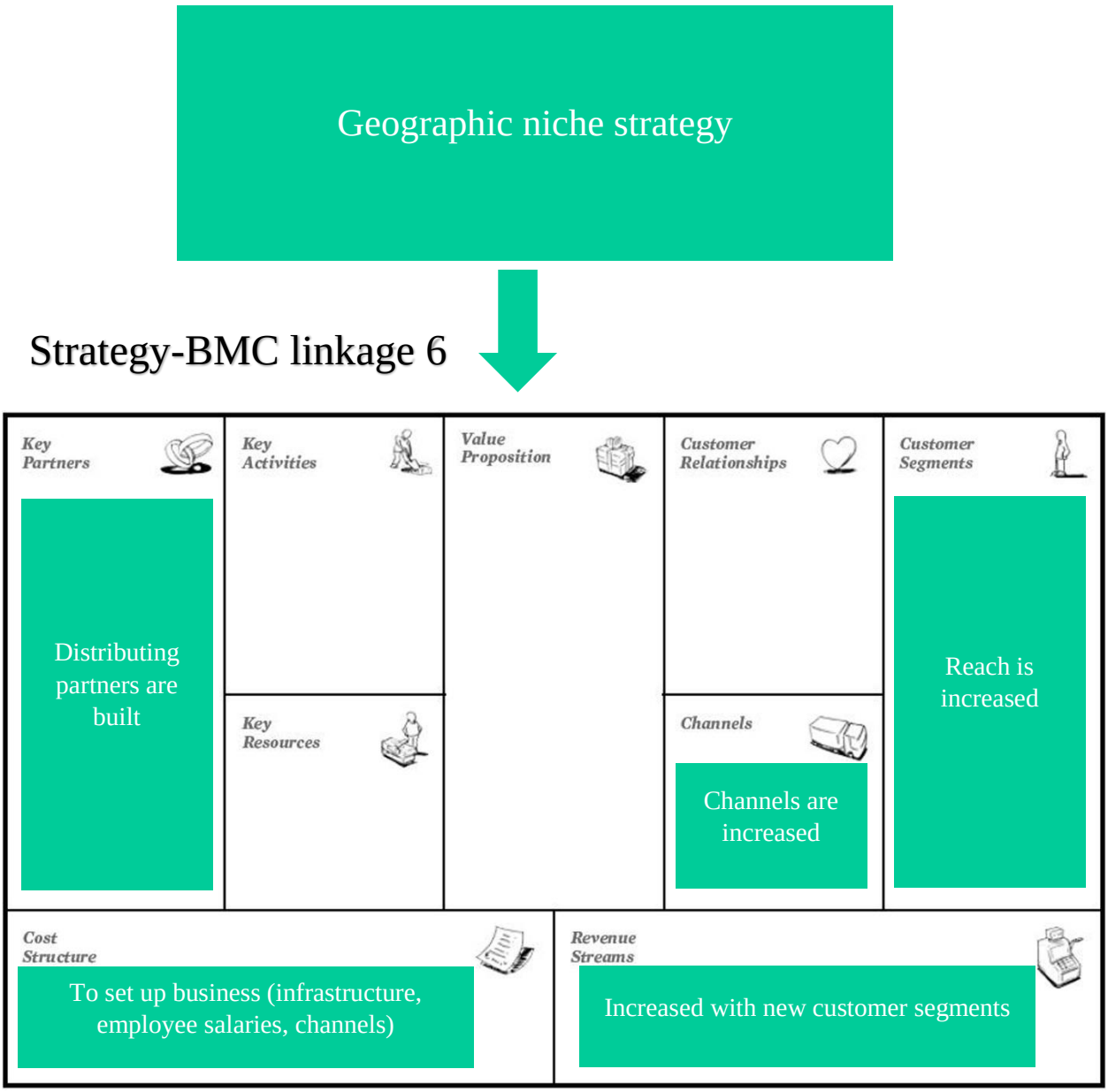

Figure 3-24 Strategy-BMC linkage 6 – Rural Spark

The geographic niche strategy is identified where the company is actively looking for partners across various geographies to increase their reach. The company has tied up with different partners in distinct regions to build their network and increase their ***channels***. The ***revenue streams*** increase as it is directly proportional to the increase in ***customer base***. This strategy is interlinked with the pilot projects as different partners in distinct geographies are first developed through pilot projects as ***key partners***. The company is expanding its operations in other regions with a similar ***value proposition*** and ***key activities*** and hence are not affected. To set up business in a new geographic location, several costs are added up in the form of infrastructure cost, employee salaries, building new channels and partners) which affects the ***cost structure***.

3.3. Philips

"A blend of awareness-availability-access to finance & after sales, this formula of success is essential" ~ Amitabh Rath, Sales Specialist, Consumer Solar

Table 3-11 Company Profile

Vice Chairman & MD India	Raja Venkataraman
Address	8th Floor, DLF 9-B, DLF Cyber City, DLF Phase- III, Gurugram, Haryana 122002, India
Contact	amitabh.rath@philips.com
Contact Persons	Amitabh Rath
Website	http://www.lighting.philips.co.in/products/solar

3.3.1. Introduction

Philips has transformed the lighting sector in the last 125 years by providing enriched lighting technologies to the world. It is a leading company in the electric, LED and smart lighting sector. Philips India recently ventured into the BoP (base of pyramid) sector in the solar home systems market. It has a PAN India presence which is enhanced by the presence of their distributors, stockiest and retailers. The research and development wing is located in the city of Noida in the National Capital Region of Delhi.

Figure 3-25 Figure has been intentionally removed

Figure 3-26 Figure has been intentionally removed

3.3.2. Closed and open questions to the Philips team

Table 3-12 Closed and open questions to the Philips team

Questions		Quotes
Interviewees		Philips Team
Open questions on barriers	Consumer awareness	Lack of awareness on Solar products, quality perspective
	Product availability	Availability of products,
	Financial	Access to purchase
	After - Sales process	It is a barrier for the industry not for us, basically the product goes into deep remote areas. It is about having the logistics network so that the people who face difficulty with the product find an easy replacement. We are providing a replacement for our product. The remote location and the user location is a challenging thing when it comes to after sales. The replacement is through stockiest/retailer.
	Technology	Easy to use Technology
	Educating partners	Partners who work on ground to educate & train end users - They are available, but they are not directly into this trade. They are basically community workers and social workers or civil society organizations or NGO's. The difficulty is about operationalizing them because they are not from the corporate background and the kind of skillset they have is totally different. It is about bringing them to one platform first.
Closed questions on barriers	Affordability	Low income of the BoP segment
	Infrastructure	Poor roads and infrastructure
	Complimentary products and services	logistics, maintenance
	Production	Not really a barrier
Open questions to strategies	Awareness	Create & Implement awareness steps amongst end user communities
	Distributing partners	Use extensive Distribution network so that products are available closer to the end user
	Product	Simple yet efficient lighting options with functionality that can be utilized keeping in mind the target segment
Closed questions on strategies	Access to finance	Multi-channel partnerships in rural set-up, Access to Finance partners. There are a lot of organizations working in the rural areas today which is all commercial reasons and they sell a lot of products in the rural areas. It could be a e-commerce provider, petroleum provider, somebody who is already having a network in that location and they kind of cross sell products to increase their revenues and their bottom line
	Service	Implement Service process, in line with organizational policy & Product warranty mechanisms ***Confidential***

Closed questions to BMC	Key partners	Organizations who provide easy finance facility to end users – Microfinance, SHG finance etc. CSR organizations who execute Rural electrification projects in villages that lack proper electricity set-up. They are looking to expand their portfolio by providing clean energy loans. So, they look at product partners so that the clients are able to get products from the companies. They are financing the end-user. There are 50+ microfinance organizations in India and we are trying to tap each one of them
	Cost structure	(Confidential), but as per industry standards, 30% - 40% of product cost added up is towards last mile distribution
	Channels	We have mult-pronged distribution strategy, from traditional trade – Stockiest – Retailer model to new age **Rural Retail partnerships & Access to Energy organizations** Access to energy organizations are working in the rural areas. They look at different products to pitch to their end users. They do solar lanterns, cook stoves, solar lights so it's about finding the mutual benefit agreement and signing them up for a channel partner
	Value proposition	Right light for the user at affordable prices & a value-for-money product with best features to light-up a rural household
	Customer segments	Rural & Semi-urban households who currently use kerosene lamps or other non-standard lighting devices are key target group. They are chosen because Solar energy offers them the right option to eliminate usage of kerosene & bring them up in the Solar Energy lighting devices ladder.

3.3.3. Barrier results

The barriers faced by Philips are categorized in influencing and core factors as described in *table 3-13*. The key barrier addressed in the interviews is the lack of awareness of solar products among the rural population. The availability of products and ease of use of technology is also cited a challenge in this market. Providing after sales service is quite a challenge as the product goes into the deep remote areas. Remote user location is often challenging to reach out and service the product. Another important challenge is to bring the partners such as NGO's, social and community workers on one platform and improving their skillset so that they can further impart education and training to the end users.

Table 3-13 List of barriers (influencing and core) faced by Philips

Indirect (Influencing) factors	Direct (Core) factors
Affordability Low income of the BoP segment	***New high-tech product (cost & quality)*** Availability of products, Easy to use Technology
Infrastructure Poor roads and infrastructure	***Production system*** Not really a barrier

	Complimentary products & services (distribution & use) After - Sales process, logistics, maintenance
	Consumer awareness & risk perception Lack of awareness on Solar products, quality perspective
	Financial Lack of access to purchase
	Educating partners Partners who work on ground to educate & train end users

3.3.4. Strategies

There are five major strategies which are identified from the interviews as discussed in *table 3-14*. The first strategy is access to finance which is to find agencies or partners to provide end user finance. Finding multi-channel partners such as the rural-retail partnerships for instance a petroleum provider, e-commerce provider is the second strategy implemented by Philips. This comes under the hybridization or adaptor niche strategy which also includes the existing distributors and access to energy organizations. The third strategy is the educate niche strategy which is about providing knowledge and training to the end-users through community workers and NGO's. The company has also initiated the process to increase the reliability and light output of the system which according to one of the experts can change the game. This is a part of the fourth strategy which is product research and development. The company has also implemented its service process to deal with any maintenance and technical challenges in the product which becomes the fifth strategy.

Table 3-14 Strategies implemented by Philips

New/ Original Strategy	Adapted/new definition
Access to finance	Access to Finance partners
Hybridization or Adaptor niche strategy	Multi-channel, partnerships in rural set-up, use extensive Distribution network so that products are available closer to the end user
Educate niche strategy	Create & Implement awareness steps amongst end user communities
Product (Research & Development)	Simple yet efficient lighting options with functionality that can be utilized keeping in mind the target segment. We have already initiated changes to increase the reliability, light output "increase in lumen output can change the game in alternative energy sources"
Service	Implement Service process, in line with organizational policy & Product warranty mechanisms

3.3.5. Elements of Business Model Canvas

The elements of the business model canvas for Philips is described in this section. *Table 3-15* presents an explorative and non-exhaustive set of business model elements obtained from expert interviews. The *key partners* are microfinance, SHG finance institutions, CSR organizations who execute rural electrification projects in villages, existing Philips distributors and rural-retail partners. The *key activities* include product development, marketing, selling, channel development and educating the partners. The *value proposition* is based on providing the right light for the user at affordable prices & a value-for-money product with best features to light-up a rural household. The *customer relationships* are maintained through partners on ground such as NGOs or social workers, distributors and rural retail partners. The key *customer segments* are rural & semi-urban households who currently use kerosene lamps or other non-standard lighting devices. The *channels* include existing distributors and stockiest

and rural retail partners. The *cost structure* data is confidential but 30% - 40% of product cost added up is towards last mile distribution.

Table 3-15 Business model canvas elements for Philips

<table>
<tr><td rowspan="3">Key Partners
Organizations who provide easy finance facility to end users – Microfinance, SHG finance etc.
CSR organizations who execute Rural electrification projects in villages that lack proper electricity set-up
Distributors
Rural-retail partners</td><td>Key Activities
Product development, marketing, sale, channel development, educating the partners</td><td rowspan="2">Value Proposition
Right light for the user at affordable prices & a value-for-money product with best features to light-up a rural household</td><td>Customer Relationships
Local service call center, through local distributor</td><td rowspan="2">Customer Segments
Rural & Semi-urban households who currently use kerosene lamps or other non-standard lighting devices are key target group</td></tr>
<tr><td>Key Resources
Product, Sales and product team</td><td>Channels
Traditional stockiest-retailer model to new age rural retail partnership & access to energy organizations</td></tr>
<tr><td colspan="2">Cost Structure
Confidential, (30-40% of the product cost is towards distribution), R&D</td><td colspan="2">Revenue Streams
Sale of SHS</td></tr>
</table>

3.3.6. Link between barriers, strategies and BMC elements

In this section, the relationship between barriers, strategies and BMC elements is studied. *Figure 3-27* graphically describes the relationship between barriers, strategies and BMC elements. The individual barriers are linked to the respective strategies as seen in *figure 3-28*. The effect of barriers on BMC elements is described briefly in *section 3.3.7*. The effect of strategies is explicitly defined in strategy-BMC linkages developed for Philips in *section 3.3.8*. These linkages bring clarity to the implications of the strategies on the business model canvas. The affected elements of BMC are clearly indicated in the strategy-BMC linkage *figures (3-30 to 3-34)*.

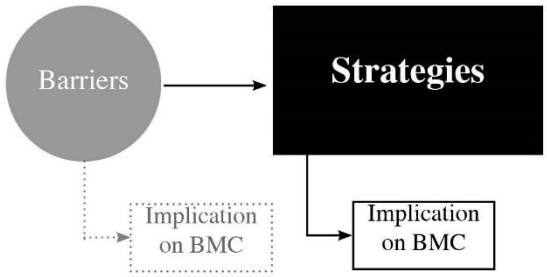

Figure 3-27 Linkage between barriers, strategies & BMC

In *figure 3-28*, the key barriers are linked to the respective strategies and are color coordinated. The lack of availability of products is linked to the hybridization or adaptor niche strategy where the company ties up with its existing distributors and rural retail partners. Low consumer awareness is linked to the educate niche strategy which is about awareness building among the end consumers. Non-

affordability and lack of access to purchase is linked to the access to finance strategy which provides access to the finance partners for consumer financing.

Figure 3-28 Barrier strategy linkage for Philips

3.3.7. Implication of barriers on the business model canvas

Non-affordability and high cost of SHS impacts the availability of consumer segments, and hence the revenue streams are blocked. Low consumer awareness has a similar impact as there are limited consumers and limited revenue. The lack of financial resources for the consumer limits the access to purchase. This leads to unavailability of consumer segments. The production system is not a barrier to the company's operations and the institutional regulations also do not seem to affect its activities. Educating partners who work on ground to train users is stated as barrier as these partners are not directly into this market. Due to this, the engaging customer segments and maintaining customer relationship is a hassle. In absence of after sales service, the customer relationships are affected and revenue streams might be hampered as the customer tends to pay only if service is provided.

3.3.8. Implication of employing strategies on the business model canvas

The implications of each strategy on the business model canvas is discussed in this section in detail. Five main strategies are discussed as mentioned in *figure 3-29*.

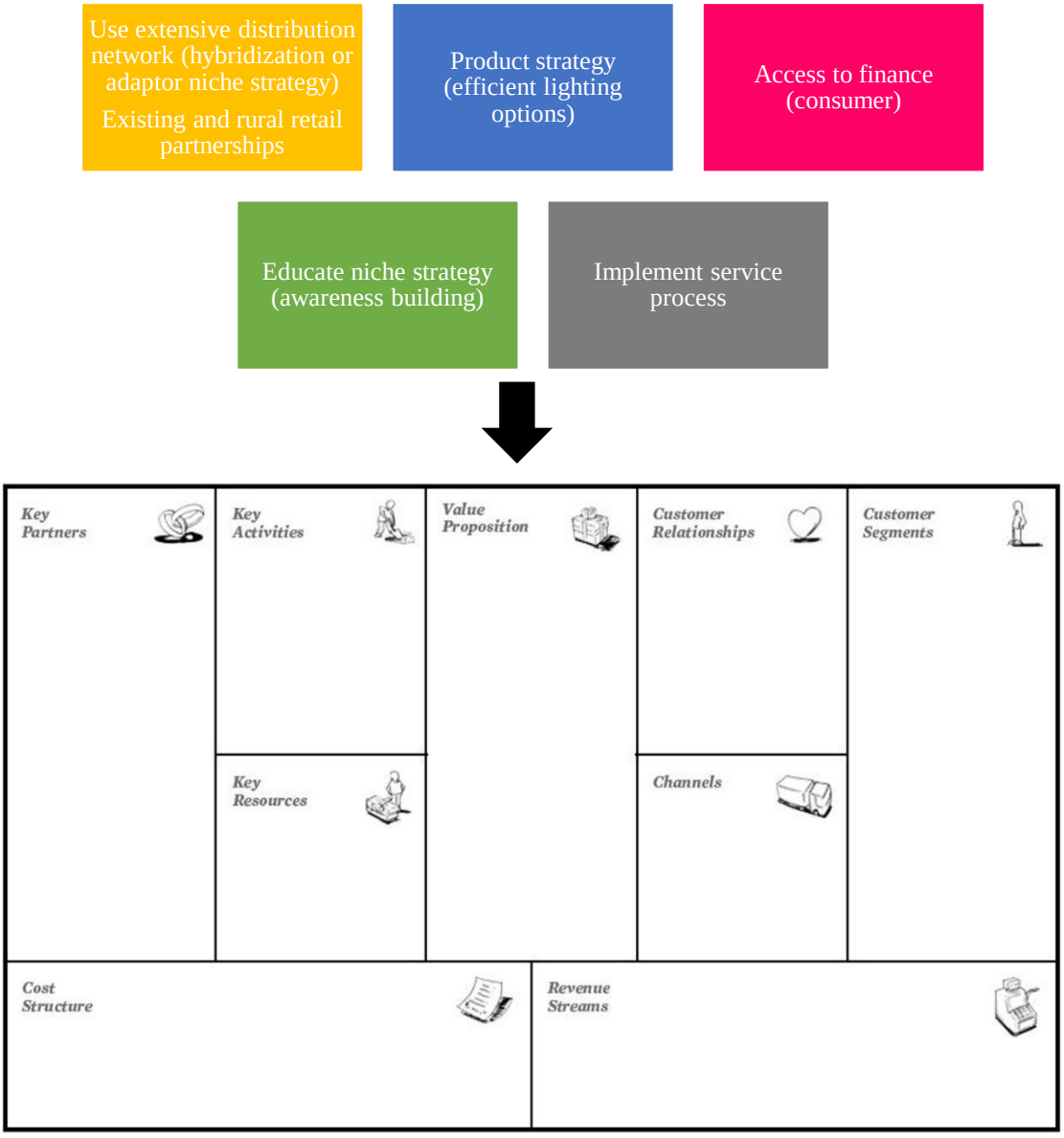

Figure 3-29 Effect of five strategies by Philips on BMC

Use extensive distribution network (hybridization or adaptor niche strategy)

Existing and rural retail partnerships

Strategy-BMC linkage 1

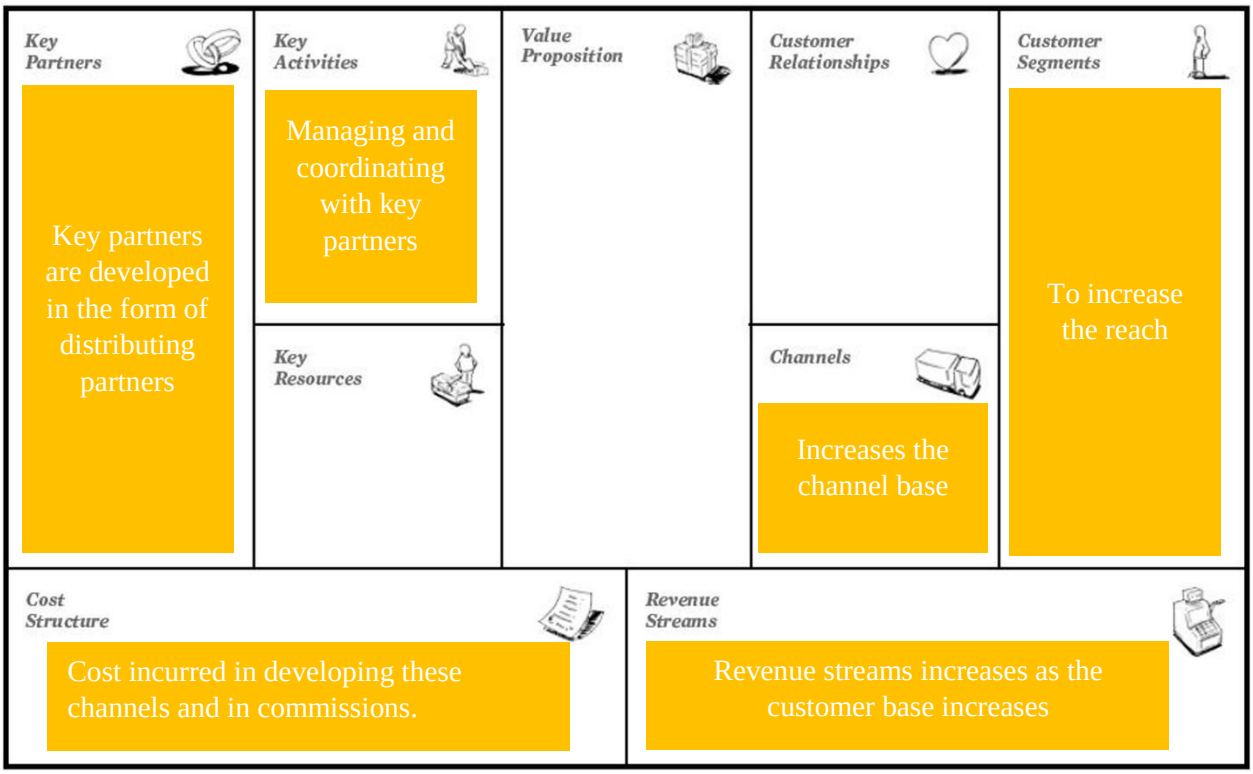

Figure 3-30 Strategy-BMC linkage 1 – Philips

Philips is leveraging its extensive distribution network which is in the form of existing stockiest and retailers. It is also building existing rural retail partners to increase its distribution ***channels***. These existing distributors are hence grown as ***key partners*** of the company. Through these channels the customer reach is augmented and hence the ***revenue streams*** are stepped up. However, in building this network certain ***costs*** are involved. These partners work on commission basis and hence add up to the cost structure. The ***customer relationships*** are not directly built with the company as the key partners are involved in between. No ***key resources*** are added to the company as this strategy focuses on key partners. The ***value proposition*** remains the same as the existing distributing help in delivering the VP through distribution of products.

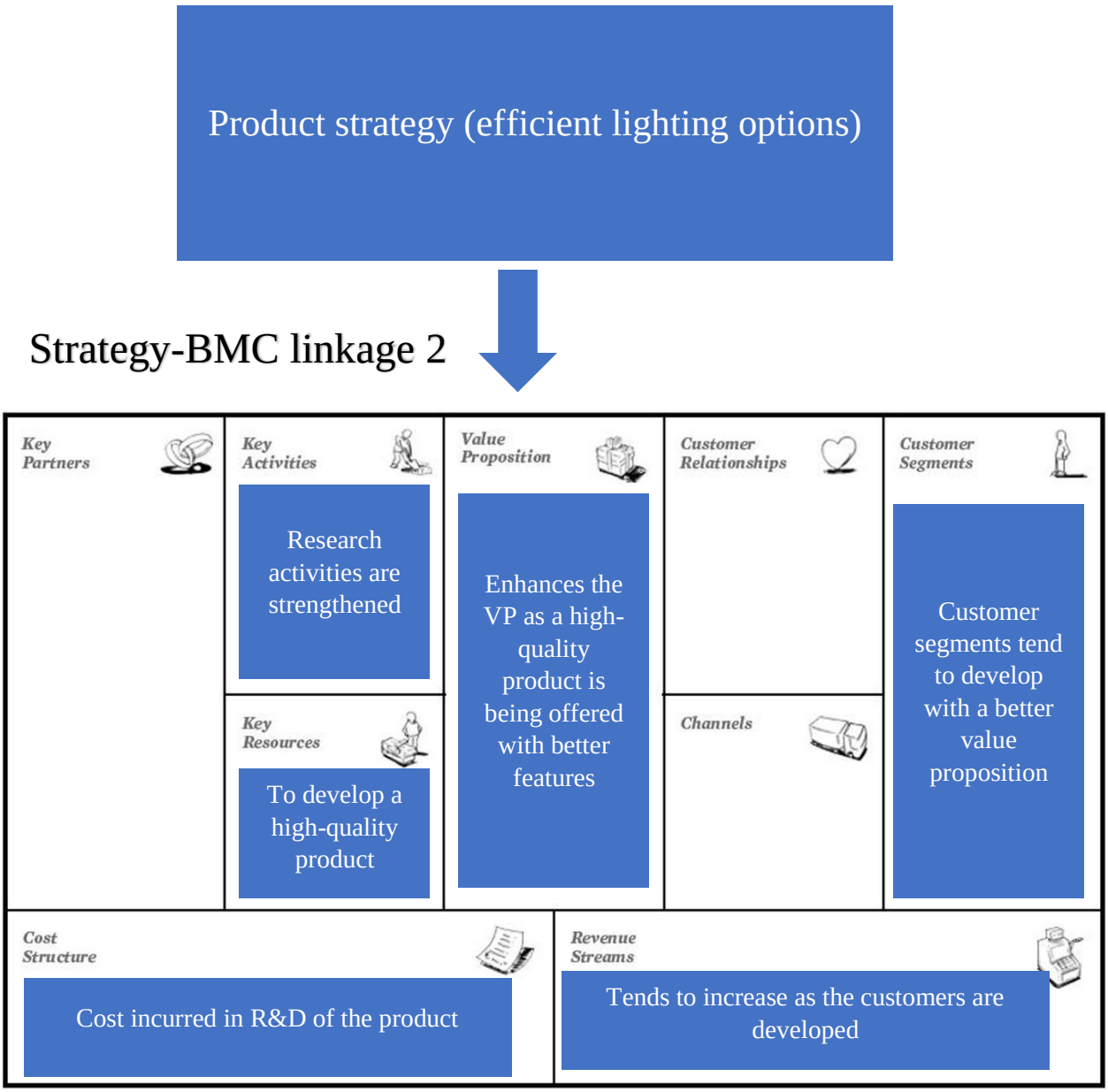

Figure 3-31 Strategy-BMC linkage 2 – Philips

The product strategy is categorized under the demo, experiment and develop strategy in the original Ortt *et al.* framework. This strategy is similar to the product strategy of Rural Spark where the ***key activities*** are research and development. A high -quality product is developed through this strategy which is the ***key resource*** of a company. There are always certain costs associated with R&D which adds up to the ***cost structure***. In addition to this, the ***value proposition*** is enhanced as a high-quality product is being offered with better features develop with this strategy which also starts to develop the ***customer segments***. This strategy becomes a part of demo, experiment and develop niche strategy in the original Ortt *et al.* framework. This is an internal strategy for the focal company hence it does not affect the ***customer relationship*** and ***channels*** for distribution. This has an indirect effect on the revenue streams which tend to develop when customer segments are increased.

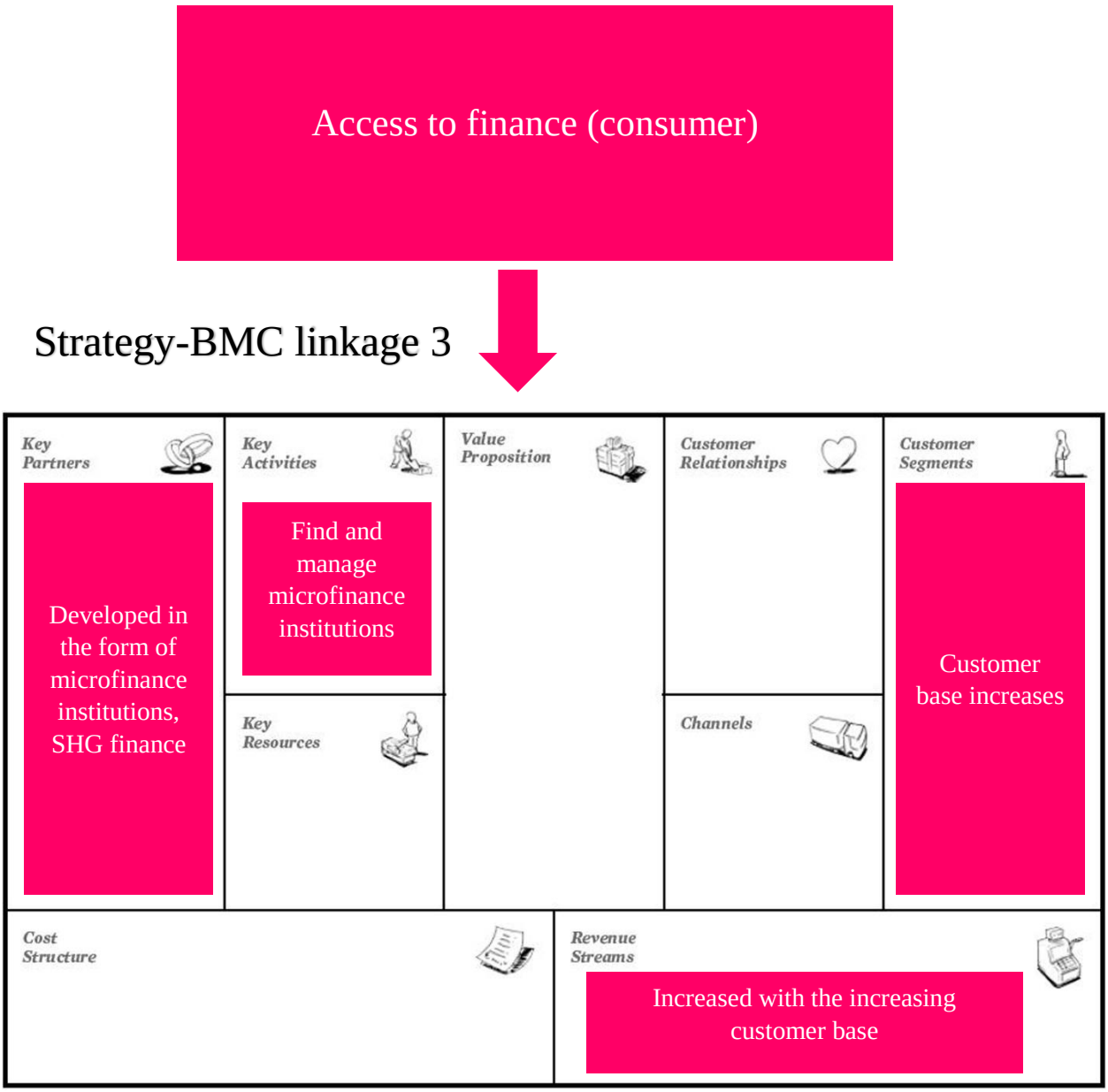

Figure 3-32 Strategy-BMC linkage 3 – Philips

The access to finance strategy helps the consumer to buy the product from the company. The microloans are provided by the ***key partners*** of the company who are the self-help groups and micro financing institutions (MFIs). This is certainly important to increase the consumer reach and to grow the revenue streams of the company. There are more than 50 micro financing institutions and the company is trying to tap each one of them. With this strategy, the ***consumer segments*** increase as they now have access to purchase and henceforth the ***revenues*** are also increased. This strategy does have any implication on the ***channels*** because there is no distribution of products involved. ***Customer relationships*** are not directly built with this strategy but rather built with a strategy followed by this which is the service and maintenance strategy. ***Key resources*** are not affected as this strategy is aimed towards providing finance to the customers. The ***key activities*** here is to find and coordinate with microfinance and SHG finance institutions.

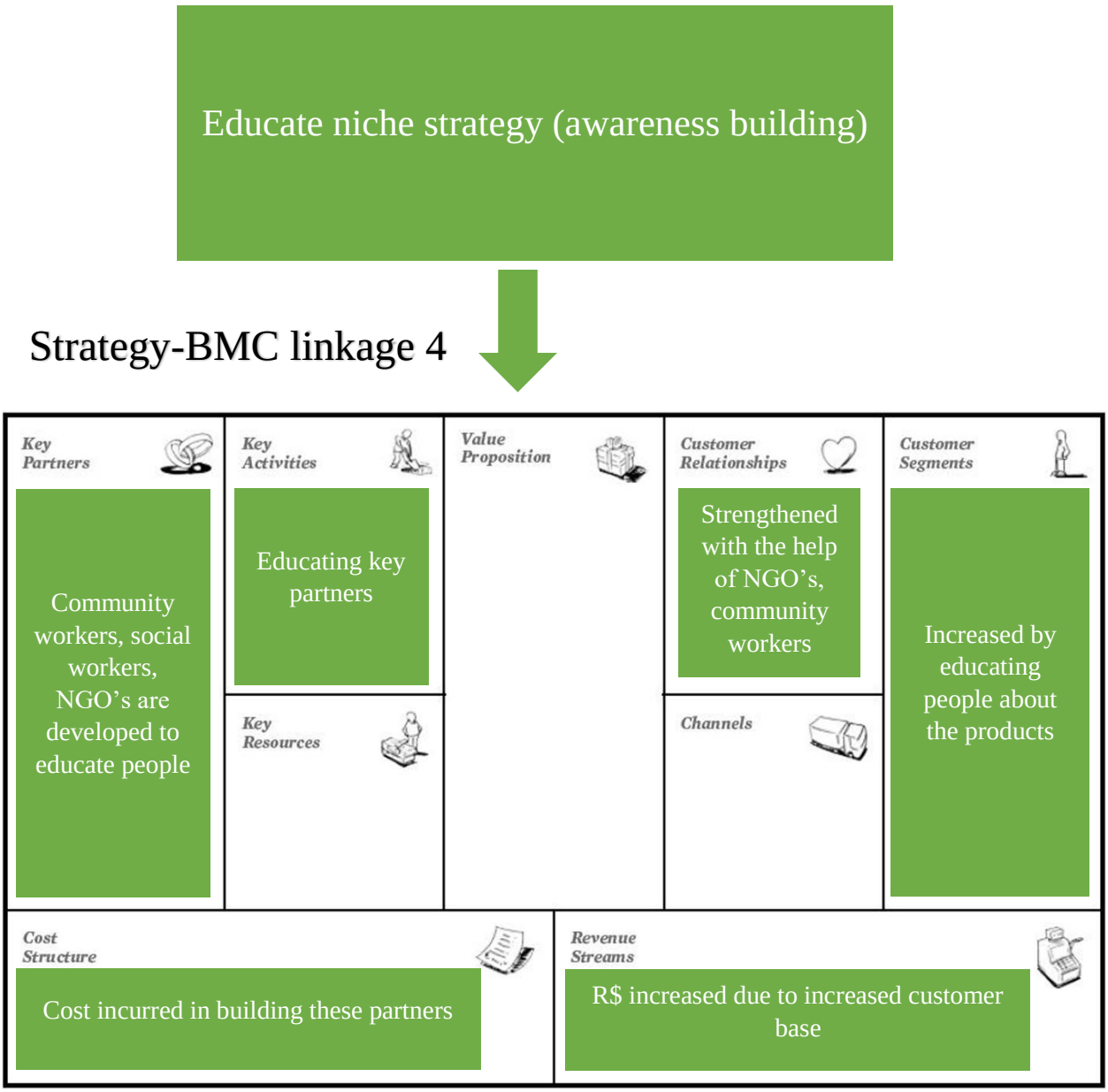

Figure 3-33 Strategy-BMC linkage 4 – Philips

The awareness building activities for consumers under educate niche strategy are done with the help of educating partners such as NGO's, community and social workers. These partners are key to develop a customer by imparting education. These education organizations are nurtured as ***key partners*** helping in increasing the customer base and strengthening ***relationship*** with them. The ***revenues*** are increased with the ***customer reach*** going up. Again, these partners are built at some expense of the company affecting the ***cost structure***. Certain ***key activities*** must be performed under this strategy which are educating these partners who can further impart knowledge to the end consumers. These partners help in delivering the ***value proposition*** but does not affect the nature of the VP delivered. This strategy does not have an implication on the ***channels*** as no distribution is involved in this strategy.

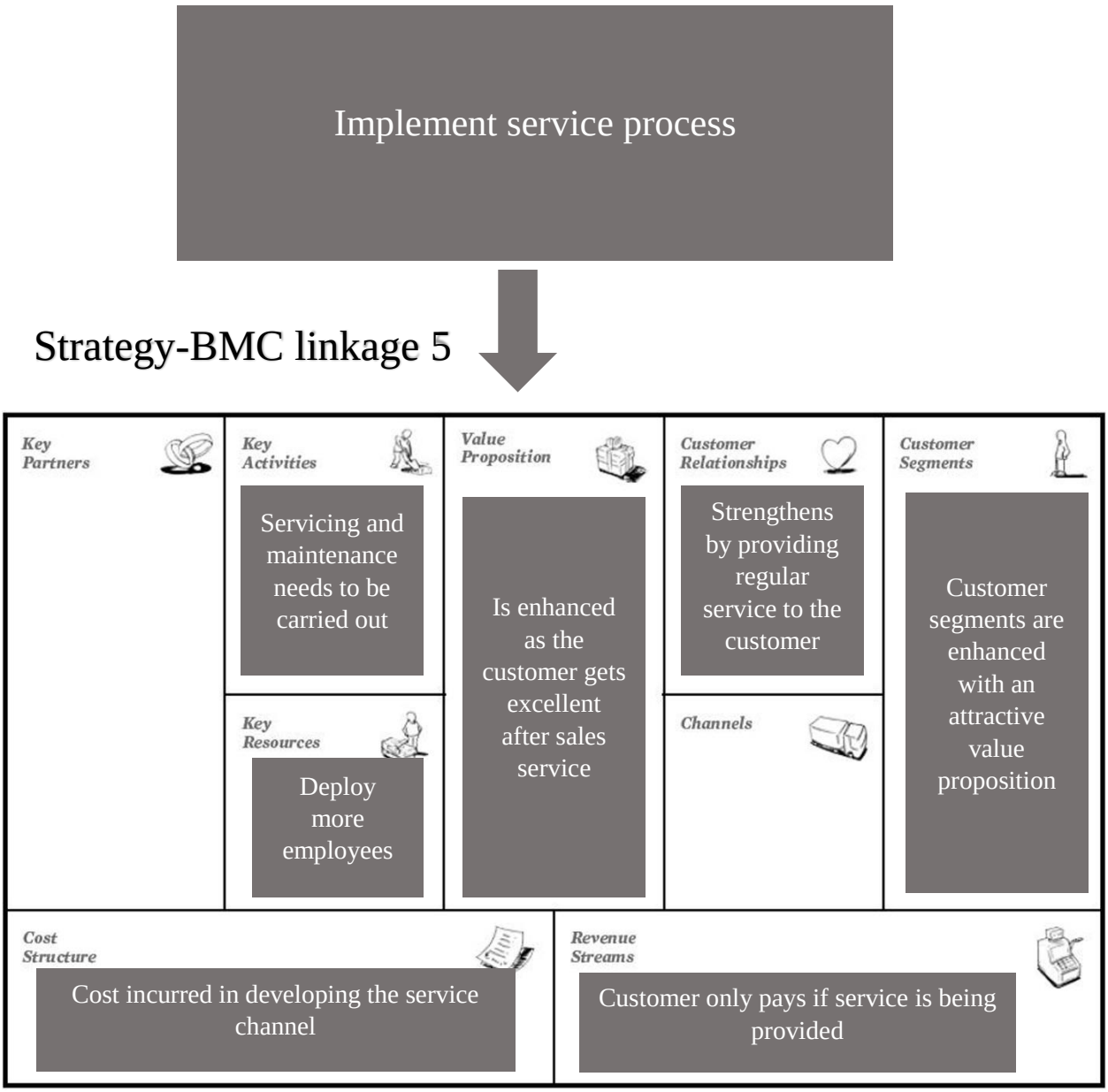

Figure 3-34 Strategy-BMC linkage 5 – Philips

The service and maintenance strategy is vital in providing after sales service to the end consumer. The ***relationship*** is improved if the strategy is implemented in the right manner. The ***key activities*** such as service and maintenance are carried out at a certain **cost** which goes into repairing and replacing the products. This cost is incurred in servicing the product and in additional workforce or **employees** who are deployed for this purpose. The ***revenue streams*** are blocked if the consumer does not get the right service. This also enhances the ***value proposition*** where the customer is offered excellent after sales service. No additional ***channels*** are built because there is no distribution of products involved. The ***customer segments*** are enhanced when they get an attractive value proposition with a service package.

3.4. Expert interview analysis

Expert interviews are conducted to understand the current market barriers and strategies in a comprehensive way. This is also done to evaluate the findings derived from literature study and case studies. The experts are identified based on their work and experience in the rural electrification market. These include Mudit Jain, a consultant from Bridge to India, Nishant from Boond and Stijn Veeger from Mr. Keepi Foundation. Bridge to India is a consultancy and knowledge service provider in the Indian renewables market. Boond is a solar energy company focusing on solar home systems and microgrids in India. Mr. Keepi Foundation works in close collaboration with Boond and acts as a financing agency for farmers in India to purchase solar home systems.

3.4.1. Mudit Jain, Consultant, Bridge to India

"These products need to be upgraded. It has to have value addition in lifestyle for 3-5 years." ~ Mudit Jain, Consultant at Bridge to India

The biggest trouble in the market is that the end customer has minimal earnings and lives in the most poverty ridden places where there is no electricity. To crack this market, companies are using the pay-as-you-go model where the money is collected in part and parcel. A challenge here arises on how to collect the payments and to stop the payment defaults where 20% people fail to pay. Moreover, in the case where the system automatically cuts the electricity when the payment is not made, people are overriding the system and using Chinese products. Another major challenge in the market is related to service and maintenance.

Figure 3-35 Barrier set 1 indicated by expert

The business projects should make economic sense

"You can always say this is a social sector and the capital grant can come in. True, that grant is available, but the business cannot run on grant money." For such businesses to take shape, it should be sustainable and economically viable. Unfortunately, this is not the case at present as either consumers cannot afford upfront cost or there is payment uncertainty for pay as you go models.

Figure 3-36 Barrier set 2 indicated by expert

The institutional challenges come if the microgrids come into play with subsidized cost of power by the government and/or with grid extension by the government. Further, when the grid is extended, power prices are heavily subsidized and it off grid products will not be able to compete.

Currently, the market is highly competitive with products being dumped in the Indian market. Most of the suppliers offer cheap product albeit with little operational life with no warranties, which ultimately spoils the consumer's experience.

Future of the industry

"The industry is heading towards oblivion, in simple sense this product is meant for underdeveloped economy with a hope that they will never get developed. This is a product meant for that market. The product must be able to meet the current and future aspirations of the growing nation."

The utility of the product diminishes once the development process starts. The product is useful in places which cannot be served with the grid. The interviewee stresses on the fact the market is shrinking very fast. And with the current government plans of electrification, it would be very difficult for a company to sustain without disrupting their business practices.

"This market is trying to sell you something which was meant to be true 10-15 years before. In essence, you are trying to sell Walkman when alternates are much superior. The long-term solution to this is to cater to the needs of the people and people's need is not restricted to basic home lighting systems."

In large solar power plants, the primary aim is to reduce the cost. In off-grid systems like SHS, the dependence on batteries is very high and it also contributes to the maximum cost share. The market might pick up again if the cost comes down but in a different format with larger storage devices.

Concluding remarks

The market needs to evolve as the current needs and aspirations of people are changing very fast. The current system needs to integrate with the existing grid in an efficient manner to give consumer a better lifestyle.

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3.4.3. Main findings

The expert interviews stressed on several barriers faced and strategies employees in the SHS market. These barriers are affordability, maintenance and service, product tampering, payment default, payment collection, grid extension, high cost, competition, awareness, road infrastructure, financial and market competition. Product tampering and payment defaults enriches the socio-cultural definition from literature which has become a major issue in these areas. Also, the grid extension and increased number of electricity hours has added a new meaning to the institutional aspects. Affordability and awareness issues as well as maintenance and service problems are well defined in literature and were confirmed by the expert interviews. The market competition is a new addition to the literature and indeed a very important factor. The market has become very competitive in terms of pricing and has created a major barrier for companies. The financial barriers remain for both end consumers and companies which is already defined in literature. Market competition has emerged to be a major barrier for the companies venturing out in the solar home systems market.

The strategies indicated by experts are access to finance for end customers. It is important to provide them with access to finance as they lack sufficient affordability. This helps in increasing the customer segments for the company. Educating people about the technology is vital to create awareness. This can be done through marketing campaigns and personal interactions. The fellow villagers act as ambassadors for the company and convince others to buy the product. These ambassadors act as key partners and play a significant role. This becomes a part of the participation niche strategy. Another aspect is related to the product upgradation. The product has to evolve with the changing conditions such as rapid grid extension. It has to meet the increasing needs and demands of people and their changing lifestyle.

3.5. Field Study

3.5.1. Field study location – Aligarh, Uttar Pradesh, India

The field study locations are in nearby villages of the Aligarh city situated in the northern state of Uttar Pradesh highlighted in grey in *figure 3-38*. Aligarh is located about 140 km southeast of New Delhi. It is known for the Aligarh Muslim University which was established in 1875 by Sir Syed Ahmed Khan. It is an important business hub for its lock industry, and these locks are exported all around the world. Hindus and Muslims comprise the major population of the city. The area of the Aligarh district is approximately 3700 sq.km. with a population of about 3.7 million.

Figure 3-38 Field study location on world map (Source: maphill.com)

3.5.2. Rural household electrification rate

India is an example of acute energy poverty with almost one fifth of its population does not have access to electricity (Hairat & Ghosh 2017) . The rural household electrification rate as claimed by the Indian government on a national scale is almost 75% which means that about 133 million rural households have access to electricity whereas 47 million rural households are lacking electricity (REC 2017). In the state of Uttar Pradesh and Aligarh district, the situation is even more serious as the electrification rate is indigent. *Figure 3-40* describes the statewise rural household electrification rate and *figure 3-41* decribes the rural households electrification rate at village level in Aligarh district (Government of India 2017).

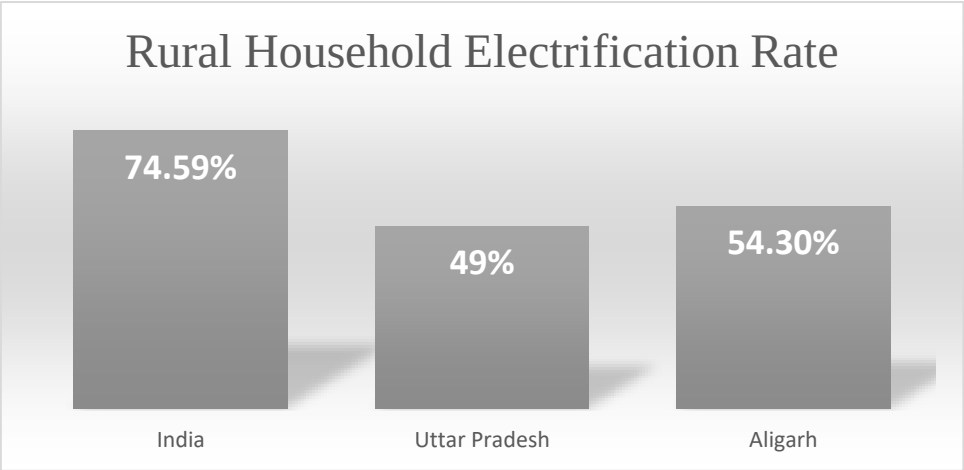


Figure 3-39 Rural electrification rate (REC 2017)

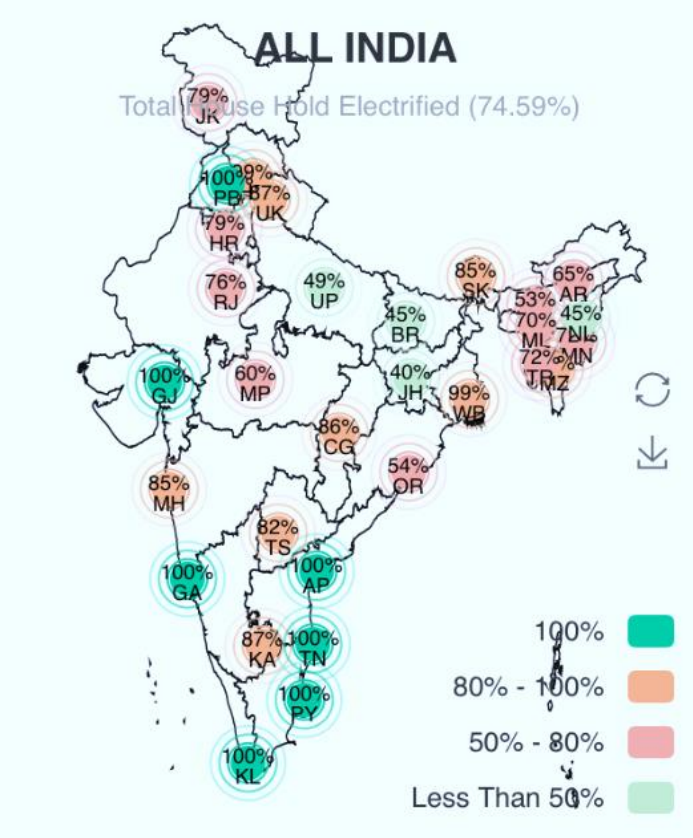


Figure 3-40 Rural household electrification rate (Source: garv.gov.in)

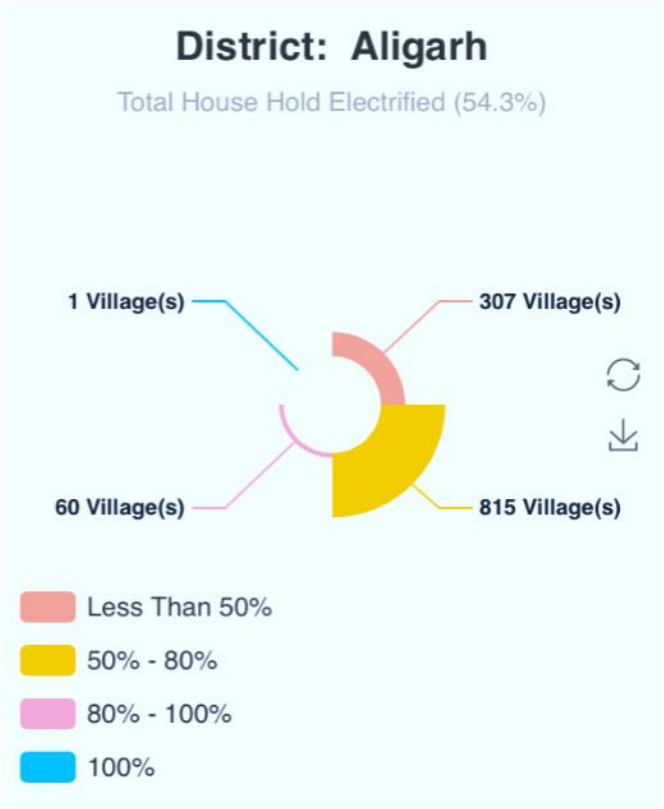


Figure 3-41 Rural household electrification rate for Aligarh (Source: garv.gov.in)

3.5.3. Solar potential in India

India being a tropical country is blessed with all forms of renewable energy sources. India receives sunshine on an average of 300 days a year with sunshine hours ranging between 2300 – 3200 per year. The irradiation ranges between 4 – 7 kWh/sq. m/day. The National Institute of Solar Energy in India estimates a solar potential of about 750 GW. The Jawaharlal Nehru Solar Mission (JNNSM) in 2010 aimed to achieve 20 GW of grid connected solar power by 2022 and now this target has been revised to an ambitious 100 GW by 2022 (Hairat & Ghosh 2017).

3.5.4. Introduction to Simpa Networks, Aligarh Branch

Simpa Networks primarily operates in the state of Uttar Pradesh in eight districts as mentioned in *table 3-18*. The field study was conducted in the Aligarh district of Uttar Pradesh. The operations are carried out from a branch office located in the city and is headed by the Area Branch Manager (ABM). There are three teams in a branch office which look after the operations, sales and credit. The total customer reach in Aligarh district is approximately 4500 where 490 systems have been fully bought. Major costs incurred are in the product, employee salaries (50-60 employees) and marketing activities.

Table 3-18 Simpa's reach in eight districts

Pilibhit	Bareilly
Badaun	Hathras
Aligarh	Kasganj
Mathura	Shahjahanpur

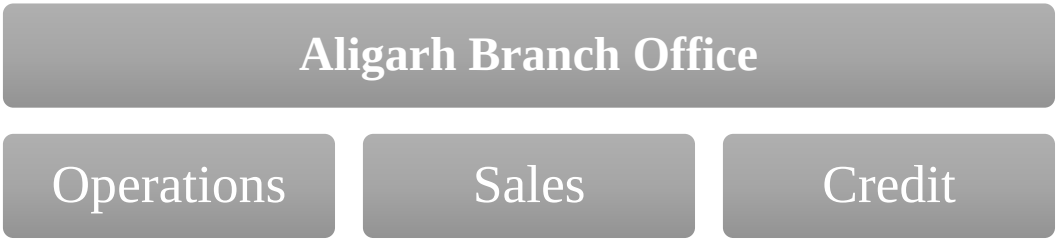


Figure 3-42 Divisions in branch office

The operations team looks after the installations and maintenance services of SHS and is also responsible for the payment collections. The credit team looks into the consumer's credit history and decides whether to sell the system to the consumer or not. The sales team has two major functions, one is to look out for potential customers and the other is to manage the Urja Mitras. The function of sales team and role of Urja Mitras are described in *table 3-19*.

Table 3-19 Functions of Simpa team and role of Urja Mitras

Functions of Operations team (Customer Relationship Associates)	**Functions of Sales team (Rural Sales Associates)**	**Functions of Credit team**	**Role of Urja Mitras**
-Installation -Service -Portfolio (payment collection, recharge) -Relationship building	-Create and manage Urja Mitras -Customer reach	-Decides whether to give the product to the customer or not based on the credit history and verification	-UM is the mukhiya "head" or influential person in the village -UM is a reliable and a reputed person and

	-To complete the sales form and partner bank form -Collection of down payment		carries on need assessment in the village for the company. -UM acts as an ambassador for the company. In return, the UM is compensated with a small commission on sale of each product.

3.5.5. Operations at Simpa Networks

The most important step in setting up a branch is performing the credit survey to assess the socio-economic conditions and payment behavior of the people. This is done by meeting banks, MFIs (Micro-finance institutions), police stations and NBFCs (Non-banking financial company) to get the credit insights of that region. Once the branch is set up, the next step is to employ the Rural Sales Associates or the sales team. The basic qualification for the RSA's is to have at least completed graduation and if experienced then selection is an advantage. The RSA's are trained under the Training Certificate Program which is an important strategy for the company. Further, these RSA's recruit Village Level Entrepreneurs or (Urja Mitras). The VLE's have been assigned a digital code which is done to track the customers brought in by them. These VLE's are also trained where they are briefed about the product, Simpa policies and are motivated to boost up the sales. It is held monthly in the respective branch or a nearby hotel. The sales process begins with the RSA's getting the sales order in a Customer Application Form which is then digitalized in the branch office. The next step is verification by the credit team who checks the credit capacity of the customer. After the approval by the credit team, installation order is released and it is assigned to the Customer Relationship Officer. The warehouse is communicated about the order and then the product delivery is planned. A CRA (Customer Relationship Associate) is assigned to install the product. A post-installation call is made to ensure customer satisfaction.

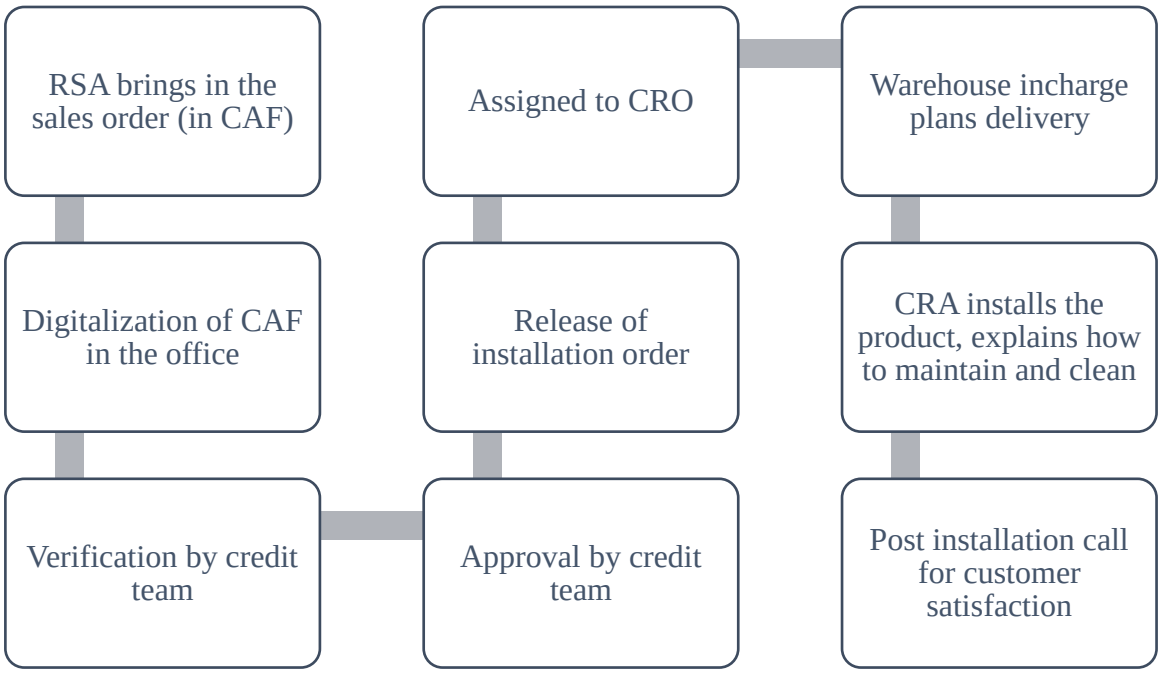


Figure 3-43 Sales process

Customer relationship building

Customer relationship is an integral part of the entire process. The CRA's (Customer Relationship Associates) build a family like relationship with the customer to ensure complete satisfaction and hassle-free payment collection. To enhance customer relationships, pre-maintenance visits are made twice a month to ensure everything is on track. Visit is also made five days prior to the due date of recharge.

3.5.6. Major Challenges

There are multiple challenges faced by Simpa as indicated by their Aligarh team. *Affordability* is a major challenge as people do not have enough buying capacity. People are unaware of the technology and products which causes a major roadblock to the diffusion process. People often refer the solar panel as "sheesha" or plain glass. *Accessibility* is another problem as to reach the customer and monitor the products in far-off places is an obstacle. There are certain technical problems such as the panel not delivering proper current or there is a wiring problem. Another barrier is regarding the *tampering* of the systems. People are misusing the product and bypass the metering technology leading to *payment defaults*. Some end consumers are also not paying their monthly installments on time again leading to payment defaults. Approximately, 20% of the customers are defaulting the payments. Currently, the electricity reliability has increased from 8-10 hours of electricity availability to 18 hours of electricity which has impacted the sales figures. For instance, if earlier the sales were 300 in a month, now they have dropped to 150. Also, with the rapid electrification in process, it poses a threat to the company's operations. Another challenge comes from the Chinese products which are available at a much lower price but with poor quality. People do not see the quality of the product but only the price. Furthermore, finding suitable talent for the field jobs is an issue which the company is facing as they reckon it is a very tough job to perform.

Table 3-20 shows a comparison of barrier results from the case study interview and field visit. The grey tick mark indicates the barrier was mentioned and the black tick mark means it was mentioned and has enriched the barrier mentioned during the case study interview or a new barrier discovered during the field visit.

Table 3-20 Comparison of factors in case study interview and field visit

Factor	Case Study – Simpa Networks	Field visit	Remarks
Natural resources & skilled personnel	✓	✓	This barrier was mentioned both by the expert interviewee and the field team.
Socio-cultural aspects	✓	✓	Payment collection is a part of socio-cultural aspect which was mentioned in the case study interview and also came up in the field visit. An additional factor which was identified in the field visit is tampering of products by end users. Also, risk of loot or theft of products during delivery is an intriguing factor which was discovered during the field visit.
Affordability	✓	✓	This factor was stressed both in the interviews and during the field study.
New high-tech product	✓	✓	The capital cost of the product is high which contributes to this factor. In the field visit, this

			factor was stressed by multiple stakeholders which makes it a very important barrier.
Institutional aspects		✓	This is the most important barrier which came up only during the field visit. Rapid electrification and increased reliability of the central grid has led to decline in the SHS sales.
Consumer awareness & risk perception	✓	✓	This factor was mentioned in the case study interview and during the field visit. However, during the customer visits it was seen that they call a solar panel as a plain mirror or glass which indicated a lack of awareness. Also, they were found to use DC fans directly on the solar panel without a charge controller. They do not understand the risk of the appliance getting damaged due to overvoltage.
Financial	✓		This barrier was stressed only during the expert interview session.
Market competition		✓	This factor was identified only during the field visit and by numerous stakeholders. This is an important barrier as the Chinese products have disrupted the market.
Infrastructure		✓	The lack of proper road infrastructure was realized during the customer visits and also mentioned by the supply chain team of Simpa. This barrier again came up only during the field visit.

3.5.7. Major Strategies

The main solutions to the above-mentioned challenges are mentioned in this section. The metering technology by Simpa is the key solution to ensure regular payments from the customers. It's a very clever piece of technology which makes the system unusable if the customer stops paying. It automatically shuts down the system in case of payment default. Also in this progressive purchase model, Simpa leases out the system to the customers for a period of 12 – 36 months which aims to remove the unaffordability barrier. The next important strategy is the appointment of village level entrepreneurs also called as Urja Mitras who help in reaching out and selling the product to the customer. They are rewarded with a commission on every purchase of the product. There are regular meetings held with the Urja Mitras where they are briefed about the products and the company policies. The other important strategy is the marketing activity which is carried out in different forms. These are stationary canopy activities, movable van activities and other marketing campaigns within the villages. The employ training program is also helpful in imparting relevant skill sets to the employees so that they are ready for the field operations. The extensive service team of customer relationship officers and customer relationship associates play a key role in providing operation and maintenance services and

payment collection. Another important strategy is the partnership with the existing distributors who have a good customer reach to sell the product. The distributor model is relatively new but successful as the channels are increased. In order to grow alongside electrification, Simpa has introduced grid compatible products which can be used during the hours when there is no electricity.

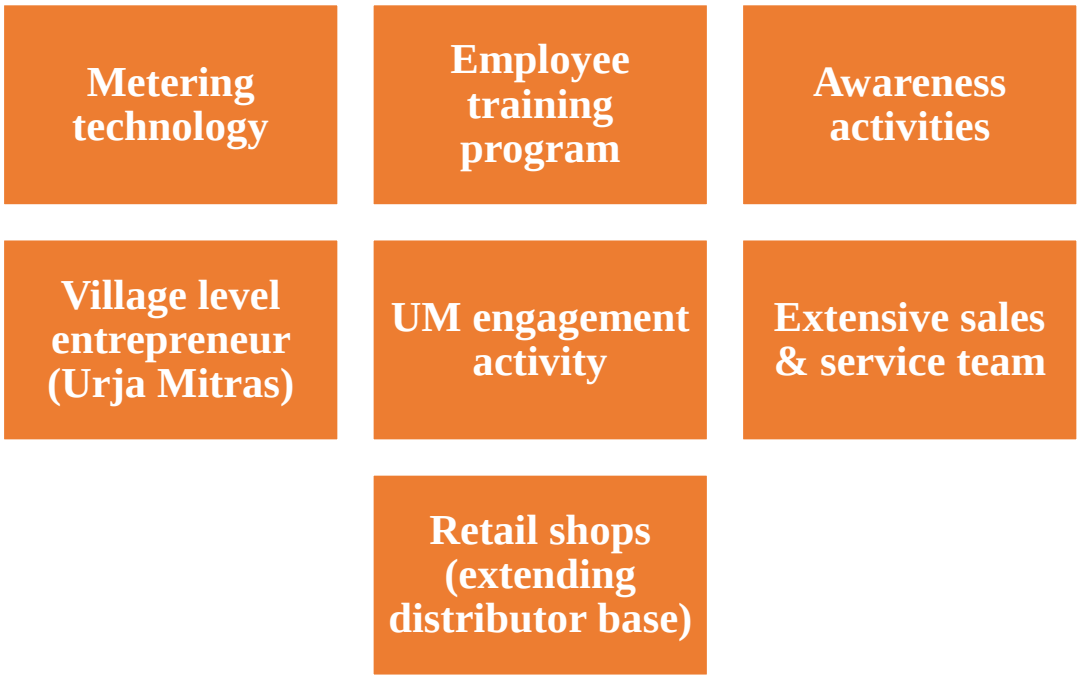


Figure 3-44 Major strategies identified during the field visit

The subsequent pages illustrate images taken during the field visit. Image 1 and 2 represents a typical rural household in Aligarh where kerosene lamp or 'dibbi' is being used for lighting purposes. The kerosene lamp has many health hazards and is a very temporary source of lighting. It is an inefficient, dangerous and expensive solution with health and environmental dangers. A rural house in which the SHS has been installed and a DC fan runs on the electricity generated by SHS is shown in Image 3 & 4. It shows the awareness and realization of sustainable technology that is trying to grow in some villagers. Image 5 and 6 displays a SHS installed on the rooftop of a house and Pradeep who inhabits the house cleans the accumulated dirt off the panel. The last two images are also exhibiting a touch of responsibility towards technology that comes along with the SHS in this young generation.

Image 7 & 8 shows marketing and awareness generated by Simpa Network officials in the form of stationary canopy activities and movable vans in different locations. Image 9 shows a local hardware shop run by a local level entrepreneur or "Urja Mitra" who acts as an ambassador of the product and helps in increasing the customer segment. Image 10 represents the regular customer visits made by the customer relationship associate to ensure proper working of the product which helps in building customer relationship. Image 11 shows an existing computer and mobile repair shop which serves as an additional distributing channel of the company. The rural sales associate brings new customers with the help of village level entrepreneurs as shown in Image 12.

Image 1 : A typical rural household without a SHS

Image 2 : Kerosene Lamp or "dibbi" used for lighting purposes.

Image 3: A rural household with SHS metering technology.

Image 4: A DC fan running on SHS

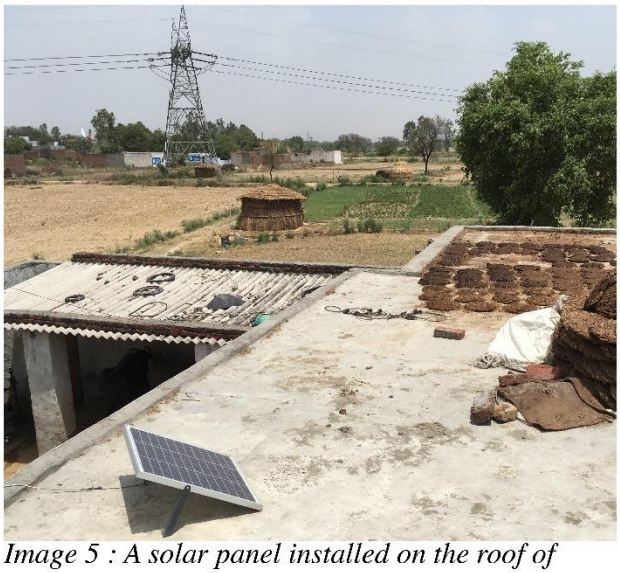


Image 5 : A solar panel installed on the roof of rural household.

Image 6 : Pradeep cleaning the solar panel installed at his house.

Image 7 : Marketing or creating awareness in the form of canopy activities.

Image 8: Marketing or creating awareness in the form of van activities.

Image 9: A local hardware shop run by a village level entrepreneur or "Urja Mitra"

Image 10: Regular customer visits by the service team.

Image 11: An existing computer and mobile repair shop as a distributor of the company.

Image 12: New customer formation with the rural sales associate.

3.5.8. Main findings of the field study and its linkage to BMC

The main findings of the field study are the challenges faced, strategies implemented by the company and their implications on the business model canvas. These findings compliment the data gathered from the expert interviews and also provide several additional and important insights. Numerous stakeholder interviews provided key findings related to the solar home systems market.

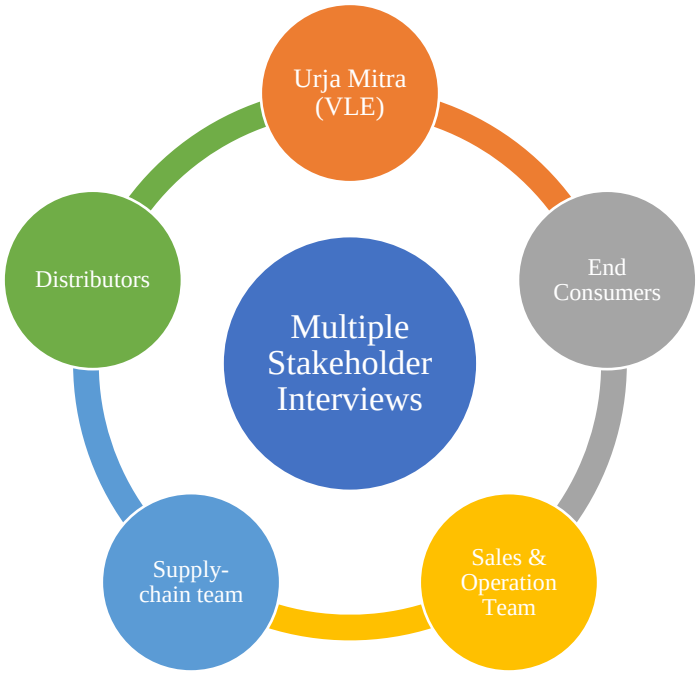
The barriers are un-affordability, lack of awareness, accessibility issues, payment default, product tampering, market competition and finding talent. Payment default and product tampering enhances the definition of socio-cultural barriers. Payment default blocks the **revenue streams** and therefore the company's profits are at stake. Product tampering is a serious concern which affects their metering technology. The **revenues** are also blocked in this case as the customer tries to avoid payments leading to default. Lack of awareness and affordability is again a key problem and has been stressed multiple times in literature and during expert interviews. Market competition from local players offering low cost and low-quality products is a major challenge for these companies. The competition also arises from rapid electrification and increased reliability of the main electricity grid which enriches the institutional barrier. This severely affects the availability of **customer segments** and hence the **revenue streams** are dampened. Finding skilled talent for field operations is a challenge for the company and adds value to the existing barrier in literature. Field jobs are attributed as tough jobs to do and hence skilled employees who are the **key resources** of the company are difficult to find. In addition to this, insights from the warehouse team adds an element to the socio-cultural barrier which is risk of theft of the material during delivery and the lack of good road infrastructure which enhances the infrastructural barrier.

The "Urja Mitra" or village level entrepreneur strategy was observed closely. It forms the part of the participation niche strategy where the "urja mitras" or VLE's act as representatives of the company and pitch their products to the potential end consumers. These VLE's are appointed as they have close relations with the fellow villagers and are influential people in the village. These VLE's are identified as **key partners** due to the role they play. They are appointed and managed by the sales team or the RSA (Rural Sales Associate). The VLE's diversify the **channels** through which the company reaches the end consumers and helps in the increasing the **consumer segments** and hence, the **revenue streams**. The "Urja Mitra" engagement activity is also considered important to motivate and educate the village level entrepreneurs. This adds value to the participation niche strategy. During the field visit, the role of the operations team was identified closely. The operations team is essentially on the payroll of the company. The operations team consists of CRA's (Customer Relationship Associates) who provide service and maintenance and carry out payment collection. The role of CRA's is important in building **customer relationship,** and they form the core part of the company and indeed are the **key resources** for them. Providing service & maintenance and payment collection is one of the **key activities** of the company performed by the CRAs. The metering technology as discussed in the expert interviews is the heart of the business model. It is a part of the progressive purchase model which is access to finance strategy for the consumers. The company provides finance to the consumers which enhances their **value proposition** but at the same time this strategy affects the **cost structure** of the company as it bears the cost of the product. The employee training program called as the "Training Certificate Program" is conducted to impart relevant skillset to the sales and operations team and forms a part of the educate niche strategy. This helps in improving the **key resources** by improving the skillset of employees. The awareness and marketing activities again form a part of the educate niche strategy from a consumer perspective. The activities are regularly held in the form of "van and canopy activities" and also in the local market called as "haat". These activities help in educating the people and build **customer relationship.** The **customer segments** are stepped up due to awareness activities. The hybridization or adaptor niche strategy is implemented in the form of engaging existing distributors who have an established customer base. These existing distributors as observed in the field visit are computer and mobile repair shops who have an existing customer base. They increase the distributing **channels** of the

company and hence increase the **customer segments**. One of the access to finance strategy is off-balance sheet financing realized through RBL Bank which is developed as a **key partner**. The bank provides upfront capital cost of the product to the company which is returned by the company in the agreed time period. The company collects installments from the consumers which are paid back to the bank. This strategy allows faster capital realization and enhances the **revenue streams**.

3.5.9. Relevance of the field visit

The field visit allowed to interact with multiple stakeholders to obtain a better understanding of the solar home systems market. These stakeholders include field operations & sales team, supply chain or the warehouse team, company's **key partners** in the form of distributors, village level entrepreneurs and end consumers. The insights gained through this visit helped in validating the interview results and also provided valuable insights which were not stated in the earlier interviews.



The field visit also allowed to explore and understand the business model canvas in a holistic manner. The role of stakeholder interviews allowed to understand the elements of the business model canvas explicitly. It helped in identifying the importance of certain **key partners** such as village level entrepreneurs, financing agencies, and existing distributors.

The role of village level entrepreneurs was stressed upon by multiple stakeholders and hence forms an important part of the company's strategy. These VLE's are trustworthy and influential people in the village and act as ambassadors for the company and therefore recognized as **key partners** in the BMC.

The role of existing distributors was also understood during the visit. They form the additional distributing **channels** of the company and hence also seen as **key partners**. The role of existing distributors comes under the hybridization or adaptor niche strategy to increase the **customer base and revenue streams**. An important insight came from this visit was the barriers faced by these key partners. This included severe market competition from the low-cost and low-quality products. This challenge faced by the distributor or key partner opens up a discussion about the barriers and strategies by the key partners in the business model canvas for the focal company. Market competition stated as a barrier by the distributor who is the key partner has direct implications for the focal company.

The importance of the sales and operations team was understood during the customer visits made with them. The company is employee-centric and within each branch of the company around 50 employees are present. They are the face of the company and hence attributed to **key resources** in the BMC.

However, the company has to invest in them, and a part of their **cost structure** is attributed to employee salaries. The role of the credit team was also understood which was not stated in the telephonic interviews. This team identifies the bankability and credit history of the customer and only after complete verification, the product is sold. This team is also an important part of the employee set and hence enhances the **key resources** description. The discussion with the supply chain or warehouse team indicated about their role and relationship with the operations team. This team ensures product delivery to end consumer and communicates with the operations team if the product has to be replaced due to technical difficulty. They also add to the key resources in the form of employees.

An institutional challenge was discovered during this field visit which is rapid electrification and increased reliability of the mains grid. This factor did not come up in the previous interviews. Due to rapid electrification, the BoP segment without electricity is shrinking very fast who are primarily the **customer segments** of this market. Another significant barrier discovered during this visit is the product tampering by the end consumers. The customers tamper the product and bypass the metering technology such that they do not have to pay for the electricity. This factor is categorized under socio-cultural aspects and therefore enriches the previous definition of this barrier. To overcome the product tampering barrier, the operations team visits the customer regularly to ensure the product safety and hence **revenue streams** are maintained as the customer has to pay when the product runs smoothly without any tampering.

The challenges indicated by the warehouse team mainly correspond to the socio-cultural aspects and the infrastructure factors in the adapted Ortt *et al.* framework. Theft/loot and family dynamics are categorized under socio-cultural aspects whereas the remote locations and poor road infrastructure correspond to the infrastructure barrier. Hence, the social barrier is enriched in the original definition and the infrastructure barrier is confirmed.

The consumer awareness barrier as mentioned in literature and interviews was noticeable during the customer visits. People do not know the functionality of the solar home systems and call a PV panel as “mirror” or “glass-plate” which clearly indicated a lack of awareness. Also, at one of the customer’s house, it was observed that the DC fan is running directly on the power generated by the solar panel without the charge controller. They do not understand the technical risk of the product getting damaged in case of overvoltage. This observation again indicated that lack of awareness among customers is a major problem.

The significance of the operations team was recognized during the customer visits as indicated earlier. They form a part of the service and maintenance strategy. They play an essential role in maintaining the products and in building **customer relationships**. They also carry out an important **key activity** for the company which is payment collection. During one of the customer visit, the payment delay barrier was noticed. This barrier is mentioned in the earlier interviews, but the role of the customer relationship associate was noticed keenly in convincing the customer to make the payments. This suggests that the role of the operations team or CRA’s is highly significant. The operations team helps in building **customer relationships** and also maintains the **revenue streams** by timely payment collection. The effect of this strategy can be seen in *figure 3-45*. The sales team has two important roles to play which form as the key activities for the company. These are directly selling to the consumer and appointing and managing the VLE’s. The prior role was discussed in the interviews, however the latter one was discussed in detail with the rural sales associates in the field.

One of the strategies related to the participation of village level entrepreneurs or the “urja mitras” is the “Urja Mitra Engagement activity” which came up only in the field study. This activity aims at training and motivating the VLE’s to sell maximum products and is usually held in the branch office or a nearby hotel. This strategy enriches the participation niche strategy earlier described for this company. Training and motivating the VLE’s helps in better performance, therefore, the **customer segments** are enhanced.

The strategies observed during the field visit compliment the interview findings and are understood more closely in this visit. The field visit helped in better evaluation of the strategies which was not possible in the telephonic interviews. Due to this, the implications of strategies on the business model canvas is also analyzed deeply. This field work adds an element of affirmation and credibility to the literature study done for this project.

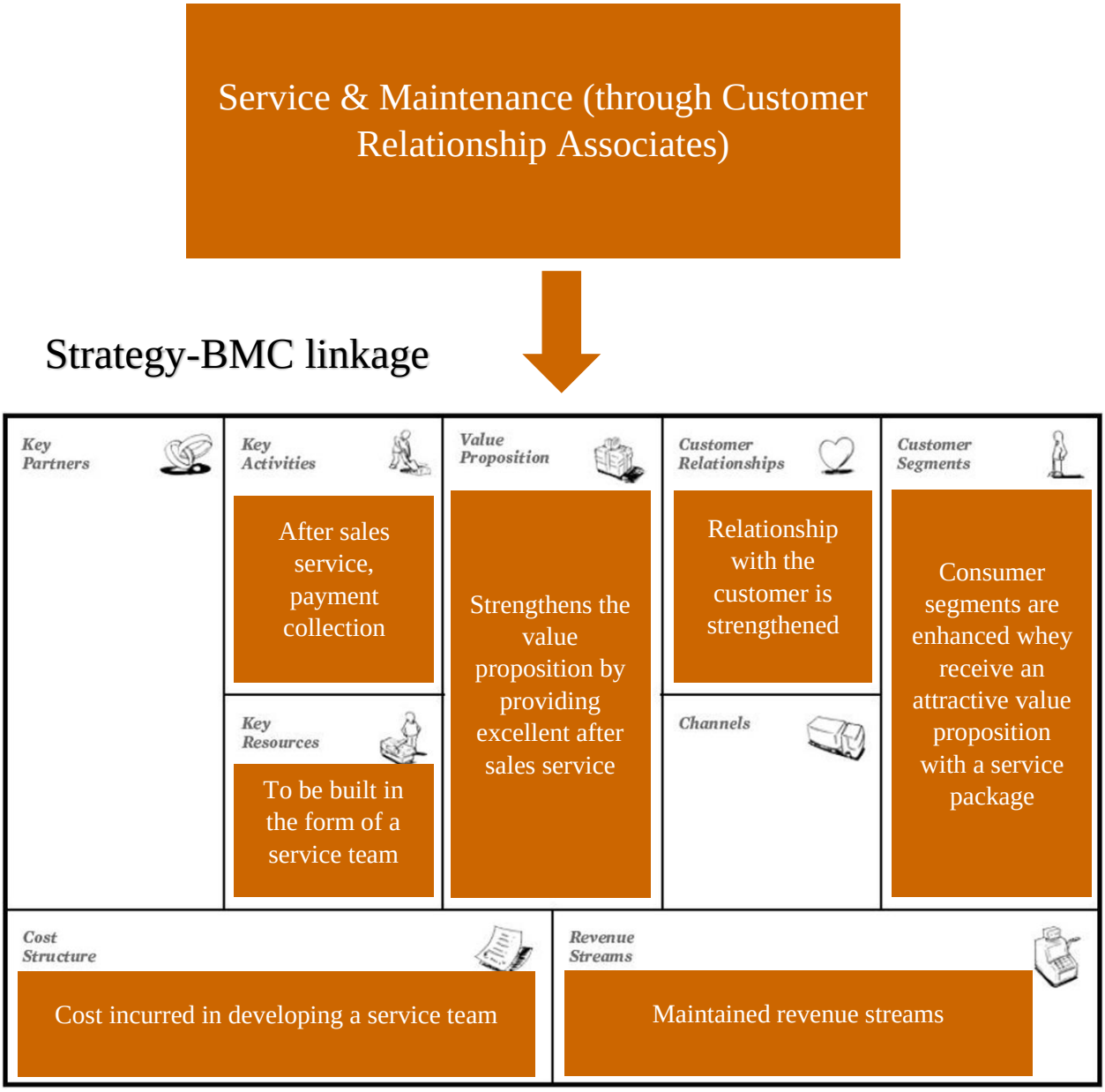


Figure 3-45 Strategy-BMC linkage (Simpa Networks)

The service and maintenance strategy allows two major **key activities** to be performed which are the after sales service and payment collection. This is done by building a team of customer relationship associates (CRAs) led by customer relationship officer (CRO) and an area service in charge (ASI). This team is important for **customer relationship** building and is attributed as a **key resource** of the company. This service strengthens the **value proposition** of the company offered to its clients. However, in building such a large team, certain costs are incurred which affects the **cost structure** of the company.

CHAPTER 4: CROSSS-CASE ANALYSIS

4. Cross-case analysis

Case studies for three companies are performed namely Simpa Networks, Rural Spark and Philips. In this chapter, the similarities and differences in barriers, strategies and business model elements for these companies are analyzed.

Simpa Networks is relatively a much-experienced company compared to Rural Spark & Philips in the off-grid solar solutions market. Simpa started its operations in 2011 and is well established in the state of Uttar Pradesh whereas Rural Spark is relatively a young company and new to the market. Philips has also ventured in the market lately, and they are just into their first year of operations.

The business model for these companies is entirely different from each other. Simpa Networks operates on a progressive purchase model or pay-as-you-go model until complete ownership. The direct customers of Simpa are the rural population with no or limited access to electricity. On the other hand, Rural Spark's value proposition is to sell the products through their premium resellers or distributing partners, and further, it is made available to the village level entrepreneurs who reach to their fellow villagers and sell electricity. Philips does not operate on the pay-as-you-go model and reaches out to the customer through access to finance organizations who provide them with micro-finance to buy the product. Simpa Networks provides this finance to customers themselves thereby also operating as a financing agency. Essentially, Simpa Networks is a blend of technology, finance and distribution company whereas Rural Spark is only a product/technology company looking for distributing partners and Philips is both a technology and distribution company looking for access to finance partners. [redacted]

Figure 4-1 figure has been intentionally removed

4.1. Barriers

Table 4-1 lists the barriers stated by the three companies.

Legend - Simpa Networks, Rural Spark, Philips, Field Visit

Table 4-1 List of barriers (influencing & core) for Simpa Networks, Rural Spark & Philips

Indirect (Influencing) factors	Direct (Core) factors
Knowledge of technology Not really an issue	***New high-tech product (cost)*** Capital cost for consumers is very high Pricing is a big barrier Availability of products, Easy to use Technology High cost of the product stressed multiple times by stakeholders
Knowledge of application	***Production system*** Manufacturing is not an issue Not really a barrier

Natural resources and skilled personnel Finding lower/middle management talent (lack of skilled workers in rural areas.) Not really an issue To find suitable talent for field jobs (sales & operations) as it is identified to be a tough job to perform	***Complimentary products & services (distribution & use)*** Enough stock in warehouses (supply chain – no problem) Finding partners as distributors After - Sales process, logistics, maintenance
Socio-cultural aspects Revenue collection is a big challenge. A lot of customers have electricity, but it is not reliable. They are not used to pay for electricity because they build illegal connections with the grid Acceptability and openness to a new product It is important, not an issue, we have to put in efforts to convince. Partners who work on ground to educate & train end users Payment defaults, product tampering, risk of loot or theft of products	***Suppliers (manufacturers and vendors of raw material, spare parts)*** Delay could be a minor challenge
Macroeconomic aspects Demonetization affected the payment collection	***Customers***
Accidents or events No such issue	***Institutional aspects (laws, rules & standards)*** We want to convey that the central and state government is supportive of solar technology and has supportive policies. Simpa works on a sustainable business model where it has not avail any subsidy on its products which existed in the past. Regulations have not caught up the market yet Not that I can think of, maybe the grid coming up Rapid electrification policies and increased reliability of the mains grid
Affordability Adoption & affordability is a challenge Big challenge Low-income of the BoP segment People do not have enough buying capacity	***Consumer awareness & risk perception*** Awareness is a big challenge Customer Awareness (to educate them), Still using kerosene, they haven't really opened their minds towards solar Is a big challenge, challenge is to explain them the proposition, the new concept, the model and to explain the finances behind it, perception related to Chinese products Lack of awareness of Solar products, quality perspective Lack of awareness among people based on how to use the technology and its applications
Infrastructure Yes Poor roads and infrastructure Lack of infrastructure such as road connectivity to reach the end customer	***Financial*** The customers belong to a segment with low affordability and the alternatives available for them in the market have a high up-front cost For companies – it is not really a barrier, the needs and capital requirement are quite limited

	Working capital in the Indian market is kind of challenging. Without that, we cannot survive. Financial resources for the end customer is very important as affordability is an issue Lack of access to purchase
Environmental	***Market competition*** Intense competition by low cost and low-quality products which has disrupted the market
Political we have not yet faced any political issue	
Business knowledge It is not a challenge, we are a LEAN company	

The similarities from the barrier perspective can be seen majorly in affordability and high cost of the system, lack of awareness among the people, lack of access to finance for consumers and poor road infrastructure. These are the four major barriers which are similar to all these three companies and also observed during the field visit. Lack of awareness among the consumers is a big challenge as they are still using inefficient means of lighting and cooking such as the kerosene lamp which has affected their health. The customers haven't really progressed and opened their minds towards adopting this technology. High cost of the system has made it less affordable for the people who want to buy the system. The high price of these solar home systems has created a road block for these companies. Lack of access to financial institutions is also a major barrier where people do not have sufficient bankability and are unable to raise loans to buy the product.

On the other hand, the institutional aspects do not seem to affect these companies as the laws and regulations have not caught up the market as learnt from the case studies. Also, manufacturing or supply related problems are not there with these companies as they have well established manufacturing and supply partners. However, during the field visit, certain institutional aspects such as rapid electrification policies and increased reliability of the mains grid is serving a challenge to the focal company operations.

Finding lower middle management staff is a challenge for Simpa Networks whereas it does not seem to affect Rural Spark's operations. This is due to the fact that Simpa is a core distribution company and managing such a large staff is difficult whereas Rural Spark is a product based company and does not require much staff. Philips has its distribution through its existing distributors and stockiest and its rural retail partners. On the other hand, finding partners as distributors for Rural Spark is a big challenge as it is a young organization and does not have enough experience in the market.

An important factor came up during the field visit but did not show up in the three case studies performed. The factor is ***market competition*** which has disrupted the market as a lot of local and Chinese products which are of low quality and low price offer strong competition to genuine high-quality products which are relatively expensive.

4.2. Strategies and BMC linkage

Hybridization or adaptor niche strategy is a common strategy to all these three companies which are being implemented in different forms. Simpa is looking for existing distributors who sell electrical goods or mobiles to sell their products and help them extend their distribution arms. This strategy was observed closely during one of the distributors visit in rural parts of India. These distributing partners serve as additional **channels** for the company. Rural Spark's main strategy is to look for premium resellers or distributing partners who have a good reach and an established network. Similarly, Philips has leveraged its existing distributing partners and stockiest from its wide business groups (lighting and

consumer lifestyle) and is engaging rural retail partners such as e-commerce providers, petrol pumps who have an established network and good reach. This strategy essentially improves the distribution **channels** of all these companies who are also identified as the company's **key partners**. This also helps in increasing the **customer segments** and hence, the **revenue streams**. Particularly for Rural Spark, the **value proposition** is strengthened as the core business for them comes through their distributing partners.

Simpa and Rural Spark have an established plan of action to procure funds and investments for the company to meet their working capital demands. Recently, Simpa partnered with RBL Bank for off-balance sheet financing. This helped them in faster capital realization in terms of faster **revenue streams** and improved their working capital. RBL is a **key partner** as financing organization for Simpa Networks and the off-balance sheet financing is a financial instrument which enhances the **key resources** for the company. Rural Spark's funding organizations are also identified as **key partners** and funding through them allows Rural Spark to perform **key activities** at ease.

Simpa Networks leases the product to the consumers thereby acting as a financing company for them. It later recovers money through monthly installments collected from the end consumer. Customer visits were made with the operations team in India for learning the process of payment collection. Philips on the other hand, arranges finance through micro-finance institutions and does not engage in the pay-as-you-go model like Simpa. Rural Spark sells its products through its distributors; hence the finances are arranged by their distributing partners. These strategies by the three companies help in increasing their **customer base** by providing financing options to the consumers. This further allows them to increase their **revenue streams** as the customer base increases. Particularly for Simpa Networks, the **value proposition** is enhanced as their business model revolves around the progressive purchase model where they lease the products to the consumers and offer an attractive financing option.

Simpa has a well-established marketing strategy which aims to educate people and create awareness about the technology. They have several marketing campaigns in the form of stationary canopy activities, movable van activities and "haat" activity (canopy at a local market) which was understood during the field visit. Awareness is also created by field officers (rural sales associates and the customer relationship associates) and the village level entrepreneurs who are also called as "Urja Mitras". Philips engages its consumers through NGO's, community and social workers and civil society organizations. It imparts relevant skillset to them which are further transferred to the end customer. Rural Spark in their pilot projects impart knowledge and awareness to the customers through their field officers and with the help of self-help groups. These strategies help in developing the **customer relationship** by client engagement activities and hence, the **customer segments** are augmented.

4.3. Categorization of company functions

As discussed earlier, Simpa Networks is a product/technology, distribution and financing company. The company has its patented metering technology, own distribution network and offers its products to consumers on lease, hence acting as a financing company. Rural Spark on the other hand is only a product or technology company which has developed its own product but relies on distributing and finance partners to reach out to the consumers. Philips is both a product and distribution company which relies on financing partners for providing access to finance to its end consumers. This relationship is described in *figure 4-2*.

Company	Product/ Technology	Distribution	Finance
simpanetworks	✓	✓	✓
IRS	✓		
PHILIPS	✓	✓	

Figure 4-2 Categorization of functions for three companies

CHAPTER 5: FINAL ADAPTATIONS OF FRAMEWORK

5. Final adaptation of framework

The final adaptation of the Ortt *et al.* framework and strategy-BMC linkage is performed in three steps in this chapter as described in *figure 5-1*. The first two steps are the barriers and strategies adaptation of the Ortt *et al.* framework and third step is the adaptation of the linkages between strategies and business model canvas elements. These adaptations are done based on the case studies, field visit and additional expert interviews.

Figure 5-1 Three dimensions of adaptations

5.1. Barriers adaptation (Stage 3)

In this section, the Ortt *et al.* framework adapted in Stage 2 *(Table 2-13)* is further adapted on the basis of insights from case studies, expert interviews and field visit. The adaptions are mentioned in *table 5-1* in *orange* color. The *socio-cultural aspects* definition is broadened by incorporating the payment default, product tampering, risk of theft/loot of products, family dynamics and electricity theft factors. The *suppliers'* barrier is broadened a bit by including the 'delay in supply of products' factor. The *institutional aspect* definition is enriched as rapid electrification policies and increased reliability of the grid serve as a major barrier to the company's operations. The consumers have perceptions related to the local and Chinese products which are cheaper but do not have sufficient quality which affects the *consumer awareness*. Another barrier added to the list of core factors is the *market competition* which has turned out to be an important barrier as it directly affects the business activities. The low quality Chinese products have disrupted the market and offers competition to these companies.

Table 5-1 Adaptation of Ortt's framework (barriers) – Stage 3

Indirect (Influencing) factors	Direct (Core) factors
Knowledge of technology *Same as in original*	***New high-tech product (cost)*** *High capital cost*
Knowledge of application *Same as in original*	***Production system*** *Original + Lack of O&M facilities*
Natural resources and skilled personnel *Original + Lack of skilled personnel*	***Complimentary products & services*** *Underdeveloped supply channels, lack of after sales services + lack of established dealer network, lack of technical support for installation and maintenance, spare parts and PV module availability*

Socio-cultural aspects *Original + Poverty, low education level, credit risk and collection concerns* *Lack of local stakeholders in decision making, lack of involvement of local communities in program design* *Payment default & product tampering* *Risk of loot, family dynamics on decision making* *Electricity theft*	***Suppliers (manufacturers and vendors of raw material, spare parts)*** *delay in supply of products*
Macroeconomic aspects *Same as in original*	***Customers*** *Same as in original*
Accidents or events *Same as in original*	***Institutional aspects (laws, rules & standards)*** *Original + Lack of adequate government policies, lack of institutional capacity, lack of information to companies on market scenario + stiff competition from conventional energy + Rapid electrification policy and increased reliability of mains grid*
Affordability *Lack of paying capacity, no income generation*	***Consumer awareness & risk perception*** *Lack of consumer awareness, high-risk perceptions, misperceptions on low quality products*
Infrastructure *Lack of infrastructure such as roads*	***Financial*** *Lack of financing mechanisms for consumers and lack of access to capital for companies*
Environmental *Local pollution, ecological issues, use of hazardous materials during production*	***Market Competition*** *– Competition from the market players selling products at lower prices but offering low quality products*
Political *Lack of political commitment, widespread corruption*	
Business knowledge *Inadequate business knowledge, lack of successful business models*	

5.2. Strategies adaptation (Stage 3)

In this section, the Ortt *et al.* framework (strategies) adapted in Stage 2 *(Table 2-16)* is further adapted on the basis of case studies, expert interviews and field visit. The adaptions are mentioned in *table 5-2* in *orange* color. The *hybridization or adaptor niche strategy* and *educate niche strategy* is further enriched by specifying stakeholders. The stakeholder are mobile recharge shops, electrical goods shop, e-commerce provider, access to energy organizations, self-help groups, social and community workers. The participation niche strategy definition is broadened by incorporating the contribution of village level entrepreneur or influential people in the village who have good customer relationships and can act as ambassadors of the company. In the *demo, experiment and develop strategy*, the focus should be on designing the product keeping in mind the current electrification status and the scope of grid connectivity in future. The *geographic niche strategy* should also focus on expanding the customer segments and building distribution partners. The service and maintenance strategy is enriched in its description as it plays a key role in maintaining a healthy product, building customer relationship and ensuring timely payments by the end consumer.

Table 5-2 Adaptation of Ortt's framework (strategies) - Stage 3

New/ Original Strategy	Adapted/new definition
Demo, experiment & develop niche strategy	A niche strategy can be adopted to demonstrate the product in public in a controlled way so the limited quality of performance is not a problem. As part of the strategy experimenting with the product is important to develop the product further, for example in a research environment. Demos and pilot projects are important to test the value proposition. Product research keeping in mind the rapid grid extension and increased grid reliability should be performed.
Top niche strategy	Products can be handmade for the top niche of the market. Top niche is supplied with a special product on priority.
Redesign niche strategy	Introduced in a simpler version with existing knowledge and resources and therefore for a lower price. To explore an application where institutional aspects are favorable. To explore an application where there is no resistance to produce or use.
Access to finance	The product is subsidized if a certain segment of consumers is considered as societally relevant. Introduce credit schemes and reduction in transaction cost (learning by doing), Formulate micro credit schems; Consumer Credit (innovative finance mechanisms along with dealers and microfinance organizations, for instance, Grameen Shakti) Providing technology to customers according to their financial status. Assistance from government and donors, Support from venture capital, private equity, international funding
Hybridization or Adaptor niche strategy	A niche strategy can be adopted by which the new product is used in combination with the old product and thereby all existing complementary products and services can be re-used. Use existing and build network of dealers for distribution of SHS. Finding these partners who have an existing customers base such as mobile recharge shops, electrical goods shop, e-commerce provider, access to energy organizations.
Educate niche strategy	A niche strategy can be adopted aimed at transferring the knowledge to suppliers.An educate and experiment (pilot) niche strategy can be adopted aimed at increasing customer knowledge. Media/personal networking, awareness and marketing campaigns, demonstrations systems. This can be also done through self-help groups, social and community workers. Training users and technicians to facilitate proper maintenance through demonstration systems.
Geographic niche strategy	A niche strategy can be adopted where institutions (laws and rules) are relatively easy to arrange or are less strict. A niche strategy can be adopted in another geographic area where resources, suppliers or customers are available. A niche strategy can be adopted in another geographic area where suppliers are available and not hampered by these unexpected events or accidents. This strategy can be also adopted to increase the customer reach and build distribution partners.
Lead user niche strategy	Lead users or innovators are co-developing the product. For instance, educated people in the village
Explore multiple market niche strategy	Multiple customer applications can be explored. For instance, in the form of different appliances to be used with the solar home system.
Lobbying	Lobby government to shape institutional environment
Participation niche strategy	Involvement of local stakeholders for instance the barefoot approach, Involvement of NGO's and private dealers. Using village heads or influential people in the village (teacher, LIC agent, shop owner) as ambassadors for their products so that the customer reach is easy.

Environmental measures	Life cycle analysis; R&D for development of efficient systems with minimum possible footprints
Service and maintenance	After sales services infrastructure for training and extension programs. To implement service and maintenance process which is key to after sales service. This can be done by deploying a service team or through partners.

5.3. Adaptation of Strategy-BMC linkage

The implication of the strategies identified from the three case studies and field study is discussed comprehensively in this section in *table 5-3*. These niche strategies are either adapted or a new addition to the original Ortt *et al.* framework according to the adaptation in the previous section in *table 5-2*. ***Seven niche strategies are analyzed for strategy-BMC linkages which came up in the case studies and field visit.***

Table 5-3 Implications of strategies on the business model canvas.

Strategy	Implication on the business model canvas
Access to finance	The access to finance strategy for consumers plays a significant role in providing end consumer finance. The ***customer segments*** are increased when they have capital or access to purchase the product. The increase in customers have a direct effect on the ***revenue streams*** of the company. Revenues are stepped up with increasing consumer base. In the pay-as-you-go model, payment collection method is added to the ***key activities*** of the business model. They key activities are also to find and coordinate with microfinancing institutions. In cases where the company leases out the product to the consumer themselves, it adds up to the ***cost structure*** as the company has to invest in the product infrastructure. The ***value proposition*** of the company is strengthened along with this strategy of providing financing to the end consumer as it an attractive offer for the consumers. The means of providing finance through microfinancing institutions or self-help groups allows the company to work closely with them as their ***key partners***. This strategy does not affect the ***customer relationships*** and does not build any extra ***channels*** for distribution of the product. ***Key resources*** of the focal company is not affected as this strategy is aimed towards providing finance to consumers.
	The financing niche strategy for companies is indeed important to procure working capital for them in the form of equity investment, debt financing and off-balance sheet financing. The ***key partners*** are hence important for these partnerships. In an event of such partnership, the key partners such as mainstream banks, development finance institutions and venture capitalists are added up. This capital allows the company to perform ***key activities*** such as manufacturing, marketing and giving off salaries to its employees. These financial resources are also the ***key resources*** which the company builds with its partners. In case of off-balance sheet financing, the ***revenue streams*** are on fast track by faster capital realization as the mainstream banks pays the company upfront cost of the product which is collected from the end consumer in the form of monthly installments. This is an internal strategy for the company hence its does not affect the customer oriented factors such as ***customer relationship.***
Participation niche strategy	The participation niche strategy is extremely relevant for successful technology diffusion in rural areas. The participation niche strategy can be implemented through NGO's, community & social workers and through village level entrepreneurs. These VLE's could be local heads or influential people in the village. NGO's, social workers and VLE's form an important

	part of the company's business model in the form of ***key partners***. The ***customer relationships*** are also enhanced through them as they act as ambassadors for the company. Through these VLE's the ***channels*** are also diversified through which the company aims to reach the customer. Additional ***cost*** is incurred in building such partners where the VLE's are compensated through commissions. This strategy definitely helps in increasing the ***customer base*** and leading to increased ***revenues***. The **key activities** include appointing and managing village level entrepreneurs. The stakeholders involved are external to the focal company and hence attributed as key partners and not ***key resources***. These partners help in delivering the value proposition but does not affect the nature of the VP delivered.
Educate niche strategy	The educate niche strategy is crucial to remove the lack of awareness and socio-cultural barriers. The educate niche strategy and participation niche strategy are inter-linked as the ***key partners*** such as NGO's, community workers, self-help groups are used as a means to impart education to the end consumer. The ***customer relationships*** are strengthened with the help of such partners and awareness programs executed by the company. The ***cost structure*** of the company is affected as it costs them money for demonstration activities, awareness programs and building these partners. This strategy helps in improving the ***consumer base*** and the ***revenue streams*** for the company. The ***key activities*** are added up as demonstrations, awareness activities and educating ***key partners*** in some cases. This strategy helps in understanding the ***value proposition*** by the customers and not affecting the nature of it. This strategy is aimed towards only educating the customers and therefore, does not have an implication on the ***channels***.
	The training and education programs to educate the employees of the company and provide them with relevant skillsets is another important strategy. With this strategy, the ***key resources*** of the company who are the employees are improved which results in better ***key activities*** such as selling, customer service and other field operations. With better key activities, ***customers segments*** can be reached in an effective manner and revenue streams can be increased. This strategy does not change the nature of the ***value proposition*** and the distributing ***channels*** as the strategy is intended only towards building skilled workforce. Also, the customer focused element which is ***customer relationship*** is not affected as this is an internal strategy of the company.
Hybridization or adaptor niche strategy	This strategy is foremost in increasing the ***customer reach***. This strategy allows a company to leverage the existing distribution network to reach out to the customer base of existing distributors These distributors are developed in the form of ***key partners*** and ***channels*** to extend the arms of the company's distribution network. However, in building a distribution network, certain ***costs*** are involved. In some cases, the ***value proposition*** is strengthened with these strategies where the distribution is primarily done through distributing partners. The ***revenue streams*** are majorly improved with the increase in such partners and end consumers through them. The customer relationship is formed with the key partner in this case and not directly with the company. This strategy is focused on increasing the distribution network and increasing the customer segments and hence does not affect the internal factors such as key resources. Managing and coordinating with these key partners is an important ***key activity*** for the focal company. The ***customer relationships*** are not directly built with the company as the key partners are involved in between. No ***key resources*** are added to the company as this strategy focuses on key partners.

Demo, develop & experiment	Constant innovation in the product is vital keeping in mind the future scenarios and demands. ***Key partners*** in the form of technology organizations and universities play an important role in supporting the research and development work. Research and development is a ***key activity*** which is strengthened due to this strategy. The product is an important part of the core business and therefore is the ***key resource*** for a company. Also, a certain part of the ***investment cost*** goes into the R&D for the product. With this strategy, the ***value proposition*** is also enhanced as a high-quality product is being offered with best features to light up a rural household. Regular demonstrations of the product in public helps in getting to know the consumer better and starts the process of developing ***customer relationship***. These demonstration activities cost a lot of money and hence affects the ***cost structure*** of the company. This strategy has an indirect effect on revenue streams which tend to develop when customer segments are increased.
	Running a pilot project is like running complete business but on a small scale. The various pilot projects are executed to test the ***value proposition***, ***channels and key activities*** of the focal company. These distributing partners in the form of channels are relevant as they are nurtured in the form of ***key partners***. The product which is a ***key resource*** of the company is also tested in this demonstration environment. ***Customer relationship*** is built through field staff of the company in the pilot projects. ***Customer segments*** are limited which results in limited ***revenue streams*** as the product is in a testing environment. The ***cost structure*** is affected as there are certain costs in running the entire pilot. This strategy allows to understand the business operations in a better way.
Geographic niche strategy	The geographic niche strategy allows the company to expand in other regions and serve a larger ***customer base***. To do this, an extensive distribution network is required which is developed in the form of ***key partners***. These key partners are again existing distributing channels who have an established consumer network. The company uses these partners in form of distributing ***channels***. This increases the ***customer base*** and hence ***revenue streams*** for the company. The company is expanding its operations in other regions with a similar ***value proposition*** and ***key activities*** and hence are not affected.
Service & Maintenance	The strategy is central in providing after sales service to the end consumer which is a ***key activity*** for any company. Maintaining ***customer relationship*** is key to this strategy. During any technical difficulty faced by the customer, this strategy is very effective. The customer only pays when the product is working and hence ***revenue collection*** is faster. This strategy demands an extensive employee network to be deployed as a service team. Hence, the ***key resources*** are increased in the form of employees. This again comes at a ***high cost*** for a company to be invested in this model. This also enhances the ***value proposition*** where the customer is offered excellent after sales service. This strategy is dedicated to customer satisfaction and no ***key partners*** are involved and no additional ***channels*** are built because there is no distribution of products involved. The ***customer segments*** are enhanced when they get an attractive value proposition with a service package.

Strategies	Elements of business model canvas								
	CR	VP	KA	KP	CS	R$	C$	CH	KR
Access to finance									
Participation niche strategy									
Educate niche strategy									
Hybridization or adaptor niche strategy									
Demo, develop & experiment									
Geographic niche strategy									
Service & Maintenance									

CR	Customer Relationship
VP	Value Proposition
KA	Key Activities
KP	Key Partners
CS	Customer Segments
R$	Revenue Streams
C$	Cost Structure
CH	Channels
KR	Key Resources

The green box represents the implication on elements of BMC

Figure 5-2 Linkage of strategies with elements of BMC

It is evident from the matrix that all the strategies are aimed towards increasing the ***customer segments*** and hence the ***revenue streams*** are increased. However, in the implementation of all these strategies, certain costs are involved which affects the ***cost structure*** of the company. It should be noted that the degree of implications on these BMC elements varies from strategy to strategy. For instance, every strategy involves different amount of costs and develops customer segments in different forms.

CHAPTER 6: CONCLUDING REMARKS

6. Concluding Remarks

6.1. Conclusion

The conclusion is presented by answering the sub-research and the main research questions. This includes the identification of barriers and strategies for the diffusion of solar home systems for rural electrification and their linkage with the business model elements. The results are achieved through research by literature study, expert interviews, three case studies (Simpa Networks, Rural Spark & Philips) and field visit to the rural parts of India.

6.1.1. Sub question 1

1. Identification of barriers

a) What are the barriers in Ortt's literature for commercializing new high-tech products?

b) How can the barriers in literature for diffusion of renewable energy products combined with the Ortt et al. framework?

The barriers mentioned in Ortt *et al.* literature can be categorized into *influencing* and *core* factors. These barriers are mentioned below in the *table 6-1*. The six influencing factors have an indirect effect while the other six core factors have a direct effect on the diffusion process of the SHS.

Table 6-1 Original list of influencing and core factors (Ortt *et al.* 2013)

Indirect (Influencing) factors	Direct (Core) factors
Knowledge of technology	New high-tech product
Knowledge of application	Production system
Natural resources	Complimentary products & services
Socio-cultural aspects	Suppliers (network of organizations)
Macroeconomic aspects	Customers
Accidents or events	Institutional aspects (laws, rules & standards)

The barriers mentioned in literature for renewable energy products, particularly solar home systems are combined with Ortt *et al.* literature on barriers and strategies for high-tech products. Several new factors have been added to the list of influencing and core factors. The factors added under influencing factors are *affordability*, *infrastructure*, *environmental*, *political* and *business knowledge*. The most distinguished adaptation is towards the socio-cultural aspects which is made more specific compared to the original definition. The sub elements to this factor are poverty, credit risk and collection concerns and lack of local stakeholders in decision making. Affordability is one of the important factors as it drives the consumers buying capacity which is very low in rural areas of developing countries. Lack of basic infrastructure such as roads hinders the company operations and accessibility towards end consumers. Another important adaptation is the lack of business knowledge because of which the company is not able to perform. This is because of the novel nature of the technology and lack of established business models. The two other factors added to the influencing factors list is environmental and political. Environmental factors is based on ecological pollution and use of hazardous substances during production. Political factors arise due to lack of political commitment and widespread corruption. The new core factors are *consumer awareness & risk perception* and *financial resources for companies & end consumer*. In the core factors list, the most notable adaptation is towards complimentary products and services which represents the underdeveloped supply channels, lack of

spare parts and lack of service and maintenance facilities. Consumer awareness is an important factor added as a completely new factor as it determines the education level and risk perceptions among consumers. Another interesting factor is the lack of financial mechanisms for both company and the consumers. Without access to capital for the company, it cannot perform its operations and key activities and without access to finance, the consumer cannot buy the product. Sub question 2

2. Identification of strategies

a) What are the strategies in Ortt's literature for commercializing new high-tech products?

b) How can the strategies mentioned in literature for diffusion of renewable energy products be combined with the Ortt et al. framework?

The strategies for commercializing new high-tech products mentioned in Ortt's literature are described in *table 6-2*. These are ten niche strategies framed for distinct market situations. The market situations are formed from a combination of influencing and core factors.

Table 6-2 Niche strategies from Ortt et al. literature

Demo, experiment & develop niche strategy	Hybridization or Adaptor niche strategy
Top niche strategy	Educate niche strategy
Subsidized niche strategy	Geographic niche strategy
Redesign niche strategy	Lead user niche strategy
Access to finance	Explore multiple markets niche strategy

Five additional strategies are identified from literature which are access to finance, after sales service, lobbying, participation niche strategy and environmental measures. In addition to this, the description for hybridization or adaptor niche strategy and educate niche strategy are slightly adapted. The subsidized niche strategy is absorbed under access to finance strategy to avoid overlapping. The access to finance strategy is important to remove the financial barriers both for consumers and companies. It is to provide subsidy, introduce credit scheme, support from private equity and international donors. The hybridization or adaptor niche strategy is discussed specifically for the use of existing distributor base who have established customers. The educate niche strategy is enriched with the methods of educating the customers and training the employees as well. The after-sales service strategies are important for providing maintenance services to the consumer. Lobbying was identified as a strategy to shape institutional environment to make it more favorable. Another distinguished adaptation is the participation niche strategy by involvement of local stakeholders including NGO's and private dealers. Environmental measures are suggested in literature for development of efficient systems with minimum possible footprints.

6.1.2. Sub question 3

3. What are the elements of a business model canvas and how are they identified?

The business model canvas is a hands-on tool to discuss and strategize business plans. The BMC consists of nine elements which are customer segments, value proposition, channels, customer relationship, revenue streams, key resources, key activities, key partners and cost structure. The customer segments define the different groups of people the company aims to reach. The value proposition is the bundle of products and services which create value for the consumer. The channels are the medium for the company to reach consumer segments. Customer relationship is established by the company in different forms with the consumers. The revenue streams represent the cash generated from each consumer. The key resources refer to the most important assets of the company. The key activities are the most important things a company must do to run their business model. The key partners are the networks of suppliers and partners that help in running the business model. The cost structure involves all costs incurred to operate a business model.

6.1.3. Sub question 4

4. What are the main barriers, strategies and business model canvas elements which are identified from the case studies and expert interviews?

The case studies indicated towards certain major barriers which affect the diffusion of solar home systems in the rural market. Three case studies were performed based on three companies which are Simpa Networks, Rural Spark and Philips. In addition to this several expert interviews were conducted to attain new insights and have a better understanding of the market. The most important barriers are categorized into influencing and core factors. The influencing factors include *socio-cultural aspects, affordability, lack of infrastructure and lack of skilled personnel*. The socio-cultural aspects were found to be diverse in nature. It involved low education levels, credit and payment collection concerns, electricity theft and acceptability and openness towards new innovations. The low-income level of the BoP segment is yet another barrier which influences the buying capacity of people. The lack of proper road infrastructure is hindering the accessibility to the end customer. Lack of skilled workers in rural areas is an important challenge for the companies which affects the key activities of the company on ground level.

The core factors include *complimentary products & services, lack of access to finance, lack of consumer awareness, institutional aspects and high cost of the product*. The complimentary products and services include finding partners as distributors and mainly the after sales process which is key towards providing service and maintenance. Lack of access to finance for consumers is a challenge and the alternatives available come with a high cost. Obtaining working capital for companies is challenging and is important to sustain in the Indian market. The lack of consumer awareness about the products is big challenge to explain the innovation and the concept behind it. The institutional aspects generally indicate towards rapid electrification policies which have posed a threat to company's operations.

Figure 6-1 Influencing factors (barriers) identified from case studies & expert interviews

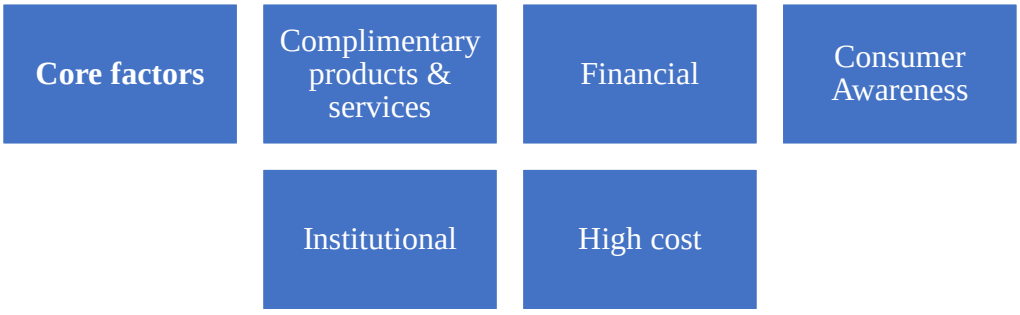


Figure 6-2 Core factors (barriers) identified from case studies & expert interviews

The main niche strategies identified from the three case studies are discussed in this section. *Access to finance* is relevant both for the consumer and the company. The *participation niche strategy* includes the role of village level entrepreneurs, NGO's, self-help groups, social and community workers. The *educate niche strategy* is to educate the end consumers and employees to provide them with relevant skillset. The *hybridization or adaptor niche strategy* is to leverage the existing distributors who have an established customer base. The *demo, develop and experiment niche strategy* includes pilot projects and research & development into the product. *The geographic niche strategy* is to increase the customer base and develop key partners. The *service & maintenance strategy* offers an excellent after sales service and implementation of the monthly payment collection mechanism.

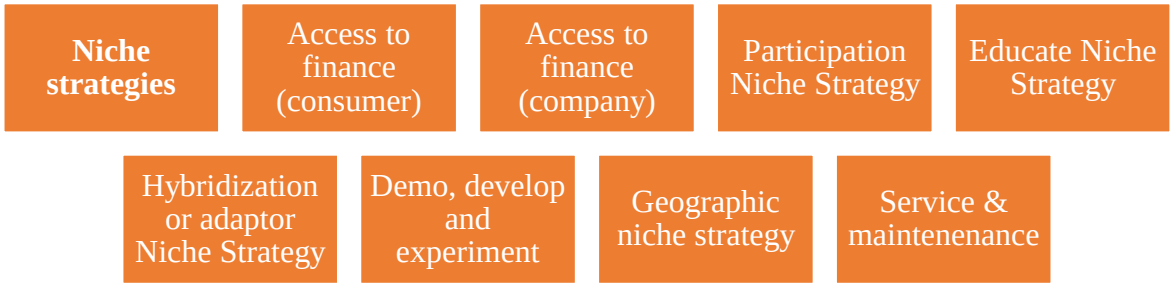


Figure 6-3 Niche strategies identified from case studies and interviews

Figure 6-4 incorporates the business model elements from the three case studies. The business model canvas is divided into nine elements as described in sub question 3. The *key partners* identified from the case studies are suppliers, manufacturers, distributing partners, financial organizations such as banks, donors and international investors. The other partners are village level entrepreneurs, educating partners such as self-help groups, NGO's and community workers. The *key activities* performed by these companies include design, testing, selling, distribution, operations, after sales service, logistics and marketing activities. The *key resources* of a company are its employees, it's product technology and the financial resources in the form of investments, debt & equity capital. The *value proposition* is about selling an efficient and a value for money product with access to finance options. The *customer relationships* are developed through field workers, village level entrepreneurs, customer service platform and local distributors. The *channels* include direct sales team and the distributing partners of the company. The *customer segments* include rural population with limited or no access to electricity. The *cost structure* consists of employee salaries, production, distribution, research and development, marketing activities and building distribution network. The *revenue streams* come from the sale of solar home systems and through distributing partners.

<table>
<tr><td rowspan="2">Key Partners
Suppliers
Manufacturers
Distributing partners
Financial organizations
Banks
Donors
Village level entrepreneurs
Educating partners (SHG, NGO's, community workers)</td><td>Key Activities
Design, Testing, selling, distribution, operations, after sales service, customer service, logistics, marketing activities</td><td rowspan="2">Value Proposition
To sell an efficient & value for money product with access to finance options.</td><td>Customer Relationships
Through field staff, village level entrepreneur, Customer service number, through local distributor</td><td rowspan="2">Customer Segments
Rural population with limited or no access to electricity</td></tr>
<tr><td>Key Resources
Employees,
Product technology,
Financial resources</td><td>Channels
Direct sales through sales team, distributing partners</td></tr>
<tr><td colspan="3">Cost Structure
Salaries, production, distribution, research & development, marketing activities, building distribution network</td><td colspan="2">Revenue Streams
Sales of SHS, through distributing partners,</td></tr>
</table>

Figure 6-4 Combined business model elements from case studies

6.1.4. Sub question 5

5. What are the main findings of the field visit in terms of barriers, strategies and linkage with business model elements?

The field visit in association with Simpa Networks was conducted in the rural areas of Aligarh, Uttar Pradesh. Simpa operates on a pay-as-you-go model until the product is fully owned by the customer. This business model is also called as the progressive purchase model. Simpa has a reach in eight districts of Uttar Pradesh touching around 25,000 customers. The field visit allowed to interact with multiple stakeholders and gain insights from them related to the SHS market at the ground level. These insights are related to the barriers faced, strategies employed and their linkage with the business model canvas.

In this paragraph, the barriers observed during the field visit are discussed. In the villages of Aligarh district, there are very few metered connections but a lot of illegal connections leading to theft of electricity. People are not used to pay for the electricity therefore it acts as a barrier for Simpa Networks. Electricity theft enriches the "socio-cultural" barrier mentioned in literature. The most important barrier is the high cost of the solar home system and unaffordability. This largely affects the ***customer segments*** of a company. A significant barrier for the company identified from this field visit is the severe competition prevailing in the market. Low quality and low-priced products are available in the market which people tend to prefer over Simpa's products. People only see the price and not focus on the quality of products, hence the ***customer base*** shrinks for the company. This barrier was also stated by one of the ***key partners*** of the focal company or the village level entrepreneurs. The electricity in the villages have now become more reliable and is available for 18-hours a day which was earlier for 8-10 hours. This has become a major barrier and diminished the need of a solar home system. In addition to this, rapid electrification of the villages which were earlier un-electrified has become a major road block for the company. This barrier was not discussed by the experts and is an important finding of this visit. Awareness is a big challenge as people still do not understand this technology and are afraid to buy a solar home system. During one of the visits, the customer mentioned the solar panel as "mirror" or "plain glass" which clearly indicated lack of awareness. These consumers were found to use the appliances such as fans directly on a solar panel without the use of a charge controller. They do not understand the risk of appliance failure. Finding talent or skilled force for the sales and operations team is a hurdle for the company as they reckon that the field jobs are a tough task to do. An important aspect which was discovered during this visit is that people have started to tamper the system thereby bypassing the entire metering technology. In this way, people use the benefits of the product and also do not pay for the electricity. This is again an important finding of this visit. This aspect did not come up earlier in the expert interviews. The warehouse team also mentioned certain barriers such as accessibility in reaching the customer and risk of theft/loot during delivery.

The strategies observed during this field visit are discussed in this section. The significant elements of Simpa's business model observed during this visit are the *"urja mitra" system (village level entrepreneur), the operations team* and *metering technology* of the company. The *"urja mitra"* system is particularly important in reaching out to the customers and convincing them to buy the system. The role of urja mitras was cited multiple times by the Simpa team and hence forms an important part of their strategy. The function of "urja mitras" and their appointment process was understood through the rural sales associates. These UMs are trusted and influential people in the village and usually work as a teacher, a local shop owner or a life insurance company agent. The "urja mitra" or "village level entrepreneur" acts as an ambassador for the product and the company and therefore is identified as a ***key partner*** in the BMC. They help in diversifying the ***channels*** to reach out to the end customers. Consequently, the ***customer segments*** develop thereby increasing the ***revenue streams***. The "urja mitras" or the VLEs help in building ***customer relationship*** which is a core element of the business model canvas. The VLEs are offered a commission for every sale realized through them. The engagement of village level entrepreneurs forms an element of the *"urja mitra"* system which came up

only during this field visit. It is an important activity to motivate and educate the VLE's about the company policies.

The *operations team* which consists of customer relationship associates (CRAs) play a significant role in performing ***key activities*** for the company. These activities are to provide after sales service to the end consumers and to collect monthly payments/installments. The relevance of this team was recognized during the field visits made with them. They are the face of the company and hence attributed as the ***key resources***. The CRAs build healthy ***customer relationships*** which ensure timely payment collection and hence the ***revenue streams*** are maintained. The sales team which consists of rural sales associates (RSAs) act as the direct ***channels*** of the company to reach out to the customer. They appoint and manage the "urja mitras" who are the key partners of the company. The relation between sales team, service team and the urja mitras is important for effective product implementation as mentioned by the onsite Simpa team.

The *metering technology* is the heart of the system as stressed by the company executives and the key partners during the field visit. The technology regulates the payment mechanism and in case of any default, it shuts down the system. This technology is therefore identified as a ***key resource*** of the company. It is the part of the progressive purchase model where the company leases out the products to the consumers and the consumers have to pay a monthly recharge amount to ensure continued supply of electricity. This model enhances the ***value proposition*** but in this case, the company has to incur a major investment in the products which affects their ***cost structure***. With this strategy, the ***customer segments*** enhance and subsequently the ***revenue streams***. These strategies are extremely relevant and important for the company to sustain in the market. This field visit helped in identifying the relation between strategies and business models explicitly as discussed above.

6.1.5. Sub question 6

6. ***How are the general barriers and strategies in the final adapted Ortt et al. framework linked to each other?***

The final adapted Ortt *et al.* framework consists of six additional influencing factors, three core factors and five niche strategies. These additional factors and strategies are derived from literature study, case studies, field visit and expert interviews. One core factor which specifically came from the case studies and field visit is the presence of severe market competition. *Table 6-3* gives the final linkages between market situations (combination of influencing and core factors) with niche strategies where the market situations adapted from literature and case studies are marked in yellow.

Table 6-3 Final linkage of strategies with influencing and core factors

Generic Niche Strategy	Influencing factors	Core factors
Demo, experiment & develop niche strategy	Knowledge of technology	New high-tech product
Top niche strategy	Knowledge of technology	New high-tech product
	Knowledge of technology	New high-tech product Production
	Natural Resources	New high-tech product
	Knowledge of technology Knowledge of application	Consumer awareness & risk perception
Access to finance	Knowledge of technology Knowledge of application	Financial (consumer)
	Knowledge of technology	New high-tech product (cost)
	Affordability	Customers
	Knowledge of technology	Financial (companies)

	Knowledge of application	
	Knowledge of technology	New high-tech product Production
	Natural Resources	New high-tech product
Redesign niche strategy	Knowledge of technology	New high-tech product Production
	Natural Resources	New high-tech product
	Knowledge of application Socio-cultural aspects	Institutional aspects
	Socio-cultural aspects	Suppliers Customers
Dedicated system or standalone niche strategy	Knowledge of technology	Complimentary products & services
Hybridization or adaptor niche strategy	Knowledge of technology	Complimentary products & services
	Resources	Complimentary products & services
Educate niche strategy	Knowledge of technology	Complimentary products & services
	Knowledge of technology	Suppliers Customers
	Knowledge of technology Knowledge of application	Consumer awareness & risk perception
	Business knowledge Socio-cultural aspects	Customers
Geographic niche strategy	Knowledge of technology Knowledge of application	Institutional aspects
	Natural Resources	New high-tech product Complimentary products & services
	Socio-cultural aspects Macroeconomic aspects	Suppliers Customers Institutional aspects
	Accidents or events	Institutional aspects
Lobbying	Knowledge of technology Knowledge of application	Institutional aspects
Participation niche strategy	Business knowledge Resources Socio-cultural aspects	Complimentary products & services
	Business knowledge Socio-cultural aspects	Customers
Lead user niche strategy	Knowledge of application	Customers
	Socio-cultural aspects Macroeconomic aspects Accidents & events	Suppliers Customers
Explore multiple markets niche strategy	Knowledge of application	Customers
Environmental measures	Environmental aspects	Production
Service & Maintenance	Resources	Complimentary products & services

6.1.6. Sub question 7

7. How can we link the niche strategies in the adapted framework to the elements of the business model canvas?

The business model canvas is used as a tool to understand the effect of niche strategies comprehensively. This effect is understood in *figure 5-2* where the strategies are mapped to individual elements of the business model canvas. This linkage between the strategies and BMC elements is a vital scientific contribution of this research. The figure brings clarity to the linkage of strategies and elements of BMC. The linkage is shown by coloring the respective cells in green. The aim of the strategies is to scale up the business operations by increasing the ***customer base*** and ***revenue streams***.

The access to finance strategy for consumers plays a significant role as it provides a means by which the customer can buy the product. The ***value proposition*** is strengthened along with this strategy of providing financing to the end consumer as it an attractive offer for the consumers. ***Key partners*** are developed in the form of microfinancing institutions or self-help groups which provide micro loans to end consumers. The financing niche strategy for companies is indeed important to raise capital for them in the form of equity investment, debt financing and off-balance sheet financing. ***Key partners*** such as mainstream banks, development finance institutions and venture capitalists are added up. The presence of working capital helps the company to perform ***key activities.*** These financial resources are also the ***key resources*** which the company builds with its partners.

The participation niche strategy can be implemented through NGO's, community & social workers and through village level entrepreneurs. ***Customer relationships*** and ***channels*** are built through these partners which are essential for a company to carry out its operations. The educate niche strategy is important to remove the lack of awareness and socio-cultural barriers. The ***cost structure*** of the company is affected as costs are incurred for demonstration activities, awareness programs and building these partners. The training programs to educate the employees of the company and to provide them with relevant skillsets is another important strategy.

The hybridization or adaptor niche strategy allows a company to leverage the existing distribution network to reach out to the customer base of existing distributor. These distributors are developed in the form of ***key partners*** and ***channels*** to extend the arms of the company's distribution network. However, in building a distribution network, certain ***costs*** are involved.

Constant innovation in the product is vital keeping in mind the future scenarios and demands and becomes a part of the demo, experiment and develop niche strategy. ***Key partners*** in the form of technology organizations and universities play an important role in supporting the research and development work. Also, a certain part of the ***investment cost*** goes into the R&D for the product. Pilot projects are important in testing the ***value proposition*** of the company.

The geographic niche strategy allows the company to expand in other regions and serve a larger ***customer base***. To do this, an extensive distribution network is required which is developed in the form of ***key partners***. The service and maintenance strategy is central in providing after sales service to the end consumer which is a ***key activity*** for any company. Maintaining ***customer relationship*** is key to this strategy.

With this matrix, it can be concluded that strategies have similar or different implications on the BMC elements. All strategies are aimed towards increasing the customer segments at the expense of certain costs which affects the cost structure but with increase in customer segments, the revenue streams increase which generates cash for the company. This tool is an important scientific contribution of this research as it develops an explicit understanding of the strategies.

6.1.7. Main research question

How can we maximize successful penetration of solar home systems for rural electrification?

Solar home system is a beneficial product in the rural areas where there is no or limited electricity. There have been several organizations and companies venturing into the market but with limited success. These organizations face critical challenges in selling the product and reaching out to the customers. There are several strategies available in literature and identified through case studies to circumvent these barriers.

Awareness among the rural populace is extremely low due to poor education levels. The community is not yet open towards this technology. One of the key strategies is to impart education and awareness to the end consumer about the technology and its application. In this way, ***customer relationship*** strengthens and the ***customer segments*** increase. This is a part of *educate niche strategy*. Another aspect of this strategy is to improve the skillset of the company's employees which can lead to better ***key activities*** like selling and servicing the product.

The high cost of the system has blocked the diffusion process in a major way thereby limiting the customer segments. To overcome the high cost barrier, companies are either financing the products to end consumers themselves or through finance partners such as local banks and micro-finance institutions. This strategy improves the ***value proposition*** and develops ***customer segments***. The *access to finance strategy* is also relevant for the companies to obtain working capital. The funding organizations for companies are in the form national and international donors, development banks, equity and debt investors and venture capitalists.

Limited supply channels and after sales service has created inefficiency within the market. Companies are trying to extend their arms of the distribution network by finding existing distributors who have a good customer reach. This strategy to leverage the existing distributor network develops new ***channels*** for the company. This strategy is a part *of hybridization or adaptor niche strategy*.

One of the key strategies that some companies are implementing is through the participation of local people who play the role of ambassadors for their products. Word of mouth publicity is extremely relevant in these areas. Through this strategy, ***key partners*** are identified who develop new ***customer segments***. This strategy has been stressed by multiple stakeholders and is pivotal in achieving market scale-up.

Research & development in the product plays a vital role as the product needs constant upgradation in terms of technology and its utility. This way, the ***key resource*** in terms of product and technology is developed. Solar home systems with the grid coming up rapidly will eventually find a common platform. Integration of the product with the grid will be key to success to the future of off-grid energy products.

The se*rvice and maintenance strategy* is key in maintaining ***customer relationships***. Their role is to service the product during any technical difficulty or product failure. They help in maintaining the health of ***revenue streams*** as the consumer pays only when the product is in a working condition.

The effect of these strategies is understood on the BMC elements to evaluate the business model critically. Different strategies affect different elements or a combination of elements in a business model canvas. This framework developed to understand the barriers and strategies and their relationship with BMC elements is an important scientific contribution of this work. The matrix is useful for the market players to comprehend their strategies along with their business models and make planned decisions based on the analysis. This will enable them to augment the diffusion of solar home systems for rural electrification in an effective manner.

6.2. Discussion

This section deals with topics which are not a part of research objectives but provide additional insights into the project. This section is divided and discussed into four parts as followed.

- 6.2.1 BMC linkage with barriers and strategies
- 6.2.2 Contributions to Ortt *et al.* theory
- 6.2.3 Barrier dynamics and linkage with BMC
- 6.2.4 Methodological contributions

6.2.1. BMC linkage with barriers and strategies

The discussion on strategy-BMC linkage is further explored and elaborated in this section. It is categorized into four subsections which are ***linkage of strategies with BMC, barriers & strategies for key partners of the focal company, qualitative & quantitative linkage of strategies with BMC*** and ***building a comprehensive model***. In the first subsection, the ***linkage of strategies with BMC*** is further explained in two ways in which the linkages can be performed. These are to enrich the exisitng strategy definition and to use BMC as an analysis tool to understasnd the effect of niche strategies. In the second subsection, the discussion on ***barriers and strategies for key partners*** of the focal company is presented which is inspired from the stakeholder interviews during the field visit in Aligarh district of Uttar Pradesh, India. Thridly, the discussion on ***qualititative representation*** of the results obtained for strategy-BMC linkages enriches the framework by adding a degree of importance to all the linkages. This degree of importance is divided into four levels which are *no implication, implication, strong implication* and *very strong implication*. Further in this section, a ***quantitative analysis*** is performed where a numeric value is assigned to the degree of imporntance used in the qualitative analysis. Finally, a ***comprehensive business model*** can be built by enriching the elements of the BMC by using the strategies and its implications.

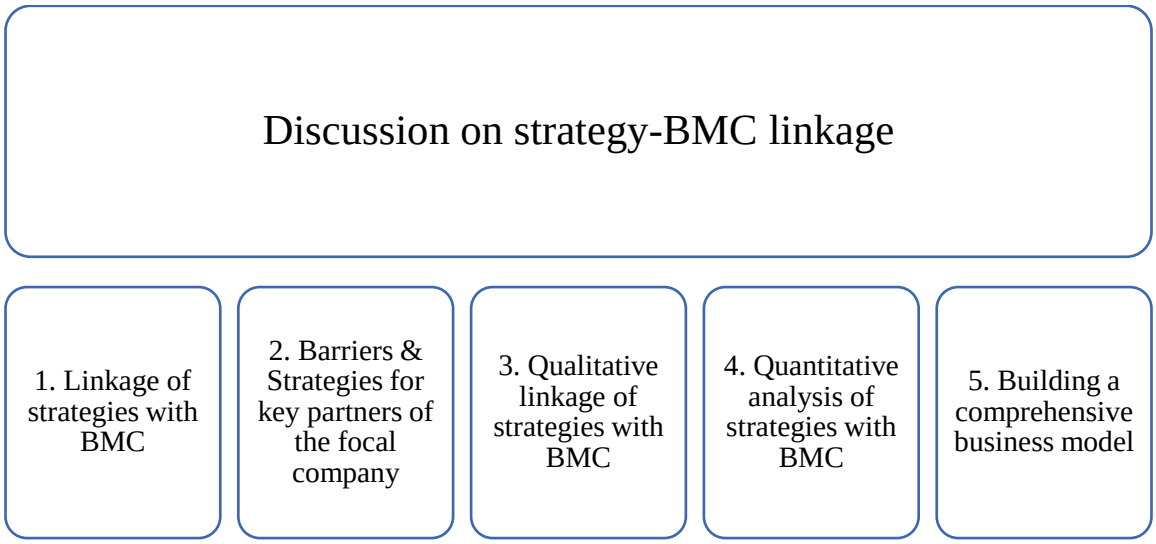


Figure 6-5 Discussion on strategy-BMC linkage

1. Linkage of barriers and strategies with BMC

The relation between the business model canvas theory and the theory on barriers and niche strategies can be identified and represented in two ways as described in *figure 6-7*. In the first representation, the business model canvas acts as an analysis tool to understand the effect of different niche strategies. In this thesis project, the focus is on the second representation in which the business model canvas is used to analyze the effect of niche strategies as explained in the previous chapters. The result of this representation is a matrix where the strategies are linked to the respective business model elements. This matrix is a comprehensive set of linkages derived from the case studies and field visit which included multiple stakeholder interviews.

In the second representation, the BMC elements helps in formulating the strategies explicitly. These elements add enrichment in the formulation of strategies which were earlier meagre in nature. The strategies are defined in terms of nine elements of the business model canvas. For instance, in this section, the hybridization or adaptor niche strategy and participation niche strategy is redefined with the help of business model elements.

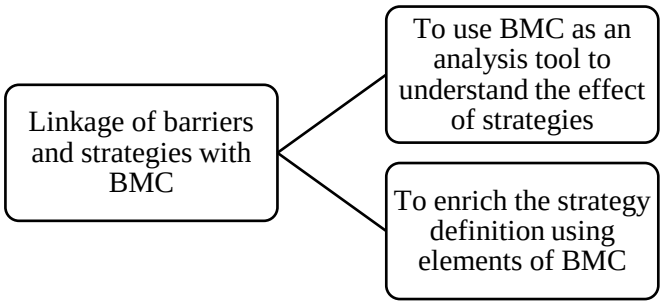


Figure 6-6 Representation of linkages between strategies and BMC elements

The ***hybridization or adaptor niche strategy*** in the original framework is the use of complimentary products and services of the old product. In this project, it is the use of existing distributors who have an established customer base and their network can be leveraged by the focal company. It can be redefined in the following way with the help of BMC elements. *The hybridization or adaptor niche strategy can be adopted where the existing distributors who have an established customer base act as additional distributing CHANNELS of the company to reach out to the CUSTOMER SEGMENTS in order to deliver a VALUE PROPOSITION. These distributing channels are essentially identified as KEY PARTNERS of the company. In building these distributing partners, certain costs are incurred which contribute to the COST STRUCTURE of the company.*

The ***participation niche strategy*** is the involvement of local stakeholders such as the NGO's in the company's ecosystem. It can be redefined in the following way with the help of BMC elements. *Participation niche strategy can be adopted to increase the CUSTOMER SEGMENTS with the involvement of local stakeholders such as village level entrepreneurs, NGO's, community workers who are identified as KEY PARTNERS to the focal company. They help in building CUSTOMER RELATIONSHIP and allow to expand the company's CHANNELS to reach the customer segments and increase its REVENUE STREAMS. Certain costs are incurred in building these partners which affect the COST STRUCTURE of the focal company. The KEY ACTIVITIES covered under this strategy are appointing and managing the local stakeholders.*

In this way, the strategies are enriched with the help of BMC elements and provide clarity to the previous strategy description. This enrichment in the strategies is because they are redefined in terms of nine components which are the elements of the business model canvas. The strategies are essentially fragmented into these components to provide a structured and well-defined meaning. This discussion to enrich the strategy definition can be further used by future researchers to conduct a detailed analysis of all the relevant niche strategies.

2. Barriers & Strategies for Key Partners of the focal company

The second aspect of discussion on barrier-strategy linkage is to look into the barriers faced by key partners of the focal company. The numerous key partners of the focal company are the suppliers, donor organizations, mainstream banks, village level entrepreneurs and existing distributors for the company. However, certain barriers faced by the key partners of the focal company were identified during the field study. One of the barriers faced by the existing distributor of the company who is also a key partner, is the ***severe competition by low-quality and low-cost products*** flooded in the market. This creates a challenge for them to serve the market. This barrier was also emphasized by one of the village level entrepreneur who is also a key partner of the focal company. Secondly, an additional barrier stated

by the distributor is the ***lack of technical knowledge among consumers***. Consumers lack the knowledge of products and its application in terms of the kind of appliances to be used with the solar home system. These barriers have a direct effect on the focal company's BMC as the *customer segments are reduced*, trust is lost in the consumers which affects the *customer relationship*. The *revenue streams* are also hit as the *customer segments* are dropped. The strategies employed by the key partners (distributors and local stakeholders in this case) are in the form of various marketing activities and educating people about the technology as observed in the field visit. These strategies have a direct implication on the *customer segments* which are augmented and henceforth the *revenue streams* are increased for the key partner as well as the focal company.

The above barriers faced and strategies employed by the key partners of the focal company open up a discussion for future research. The barriers faced and strategies employed by key partners recognized in the BMC for the focal company and its implications on the focal company's BMC could be a potential research topic as discussed in the recommendations section. The barrier-strategy sets and their implications can be identified for other key partners such as suppliers, financing partners, technology partners and others. *Figure 6-8* represents how the effect of the barriers faced and strategies employed by the key partners can have an implication on the focal company's business model canvas.

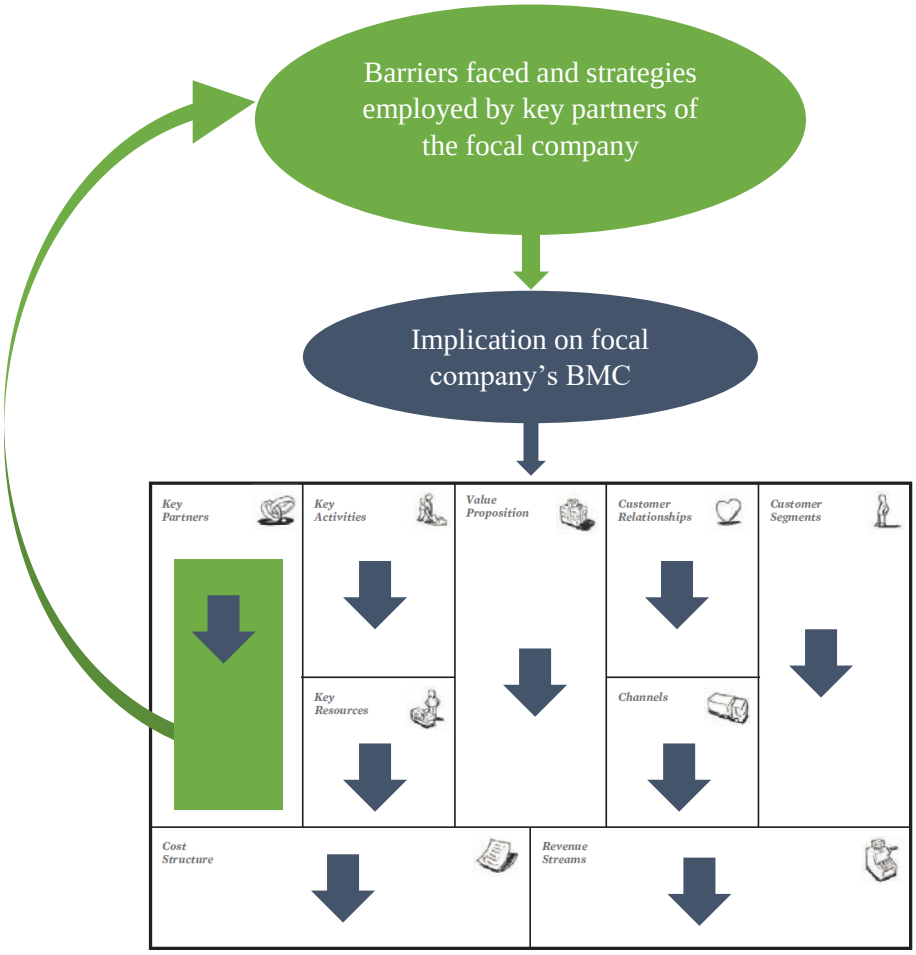


Figure 6-7 Linkage of barrier & strategies to key partners in BMC

3. Qualitative linkage of strategies and BMC

The qualitative effect of strategies can be understood in addition to the linkages formed for strategies and BMC where BMC is used as an analysis tool to understand the effect of strategies. The effects are categorized into three level based on the author's inferences from the interviews and observations from the field study. These levels are defined as *No Implication*, *Implication*, *Strong Implication* and *Very Strong Implication*. In this way, the effect of the strategies can be understood clearly. With the categorization of linkages on importance levels, it becomes easier to evaluate the strategies in terms of degrees of implications. These implications are described in *figure 6-9* which is derived by the author from the results in *figure 6-5*. The following seven descriptions of the strategy-BMC linkages throw light upon the qualitative characteristics of the same.

Access to finance strategy has a *very strong* implication on the value proposition as it is indeed essential to provide financial access to end consumers when they lack affordability and when the price of the product is high. With this strategy, the value proposition is improved significantly as the product is offered with an *access to finance* offer. This also has a *very strong* implication on the cost structure of the company when it leases the product to the consumer and the entire cost of the product is borne by the company. When the focal company receives financial aid, the key resources are improved significantly as financial instruments in the form of debt or equity capital, off-balance sheet financing and investments from other sources. The strategy has a *strong effect* in increasing the customer segments as the value proposition is enhanced which further increases the revenue streams. The key partners are also enhanced *strongly* as they are vital in providing consumer finance and finance to the focal company.

The *participation niche strategy* has a *very strong* implication on customer relationship as it plays a pivotal role in reaching out to the customer through local stakeholders such as village level entrepreneurs and build trust among them. With the implementation of this strategy, the customer segments and the revenue streams are enhanced *strongly*. Also, it has a strong implication on the channels which are increased as the local stakeholders are helping in reaching out the customer base. The key activities are also important for the focal company which are to coordinate with and manage these stakeholders.

The *educate niche strategy* has a *strong* implication on four elements which are CR, KA, KP and C$ and a *very strong* implication on CS. The customer segments rapidly increase when they have access to information and knowledge of technology. The customer relationship is enhanced *strongly* while interaction during the awareness programs and trust built within the consumer. The cost structure is affected *strongly* as its cost a lot of money to organize key activities such as marketing and awareness programs. Key partners are important for some organizations which help in creating awareness among the rural populace.

The *hybridization or niche strategy* has a very strong implication on the channels for reaching out to the customer. The channels are added and developed with this strategy and leads to a bigger network to reach the customer segments. The key partners are also important in this strategy as they are the existing distributors whose network is leveraged for distribution of the focal company's product.

The *demo, experiment and develop niche strategy* has a very strong implication on the key resource of the company which is the product and technology developed in this case. With constant research and development, the product is improved and developed which is a result of this strategy. The key activities are also important which is undertaken during the pilot projects where customer engagement and partner development is important. The cost structure in *geographic niche strategy* is affected strongly as entire business infrastructure has to be set up in new geographic location.

The *service and maintenance strategy* has a very strong implication on CR, VP and C$. The customer relationships are strengthened due to the regular visits by the service associates. This strategy also strongly affects the value proposition which is developed in the form of additional services being offered

with the product. The cost structure is affected strongly as a lot of investment has to be made in developing the service channel and managing a large team of service associates.

This qualitative analysis can be further explored in future research projects where each implication can be supported with evidences from the case study interviews and field study. In the next section, a quantitative analysis is performed on the strategy-BMC linkages which is interlinked with this qualitative analysis. In the current section, the linkages are attributed *as no implication, implication, strong implication* and *very strong implication.* Now in the quantitative analysis section, the implications are assigned a value for each implication level as hypothesized by the author. The actual ranking levels for the implications can vary based on the research methodology. Here, no implication is assigned as 0, implication as 1, strong implication as 2 and very strong implication as 3.

Strategies	**Elements of business model canvas**								
	CR	VP	KA	KP	CS	R$	C$	CH	KR
Access to finance									
Participation niche strategy									
Educate niche strategy									
Hybridization or adaptor niche strategy									
Demo, experiment & develop									
Geographic niche strategy									
Service & Maintenance									

CR	Customer Relationship
VP	Value Proposition
KA	Key Activities
KP	Key Partners
CS	Customer Segments
R$	Revenue Streams
C$	Cost Structure
CH	Channels
KR	Key Resources

No Implication | Implication | Strong Implication | Very strong implication

Figure 6-8 Qualitative analysis of strategy-BMC linkages

4.1. Quantitative analysis of strategy-BMC linkages

In this section, a quantitative analysis is performed on strategy-BMC linkages. Values are assigned to each linkage, where *no implication* is assigned as 0, *implication* is assigned as 1, *strong implication* as 2 and *very strong implication* as 3. The quantitative analysis is another method to analyze the effects of strategies explicitly by assigning numerical values to the implications and to conduct statistical analysis. In *figure 6-10*, a quantitative analysis for access to finance strategy is performed in a radar chart and in *figure 6-11*, two strategies are compared based on their implications. The radar chart in both the figures is divided in four levels, 0 at the center while 1, 2 & 3 are increasing radially outwards. The **access to finance strategy** has a *very strong implication* (level 3) on KR, VP and C$; *strong implication* (level 2) on CS, R$, KP; *implication* (level 1) on KA and *no implication* (level 0) on CH and CR as derived from *figure 6-10*.

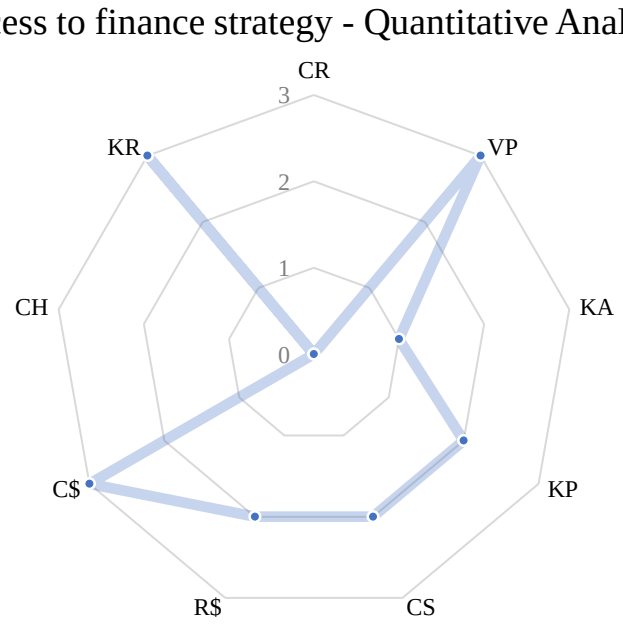


Figure 6-9 Access to finance strategy - quantitative analysis

In *figure 6-11* on next page, the implications of two strategies (*access to finance* and *participation*) on the BMC are compared and analyzed quantitatively. It gives a clear comparison of the strategies by indicating which strategy has implication on which BMC element and by how much. The customer relationship is enhanced by the participation niche strategy but the access to finance does not have any implication on this element. The key resources in the access to finance strategy are added in the form of financial instruments (equity, debt or off-balance sheet financing) whereas the participation niche strategy does not affect this element in the BMC. The participation niche strategy has a strong implication (level 2) on channels (CH) but on the other hand the access to finance strategy does not seem to affect the channels in BMC. Similarly, the value proposition (VP) is enhanced very strongly (level 3) with the access to finance strategy whereas the participation niche strategy does not affect this element. The key activities can be performed with access to working capital and is strongly affected with this strategy whereas the participation niche strategy has a level 1 implication on the key activities which are appointing and managing local stakeholders. The cost structure is affected very strongly (level 3) with access to finance strategy as the company leases out the products by themselves and bears the entire cost of the product whereas the participation niche strategy has a level 1 implication on the cost structure which comes in the form of building the network of local stakeholders and their commissions. The common region specifies equal amount of implication on the respective elements which are revenue streams, customer segments and key partners (R$, CS and KP) in this case. This tool

allows to understand the implications for one strategy by comparing them to another on a relative scale. Similarly, other strategies can be compared with the help of this quantitative analysis tool to understand their implications in a better manner. This tool can also be used to compare two similar strategies and examine their effects on the elements of the BMC. For instance, the educate niche strategy can be implemented in different forms such as marketing in the form of stationary canopy activities or movable van activities, media or personal networking and through NGO's and community workers. Now, these different marketing activities can be compared and plotted on this tool. This will enable the market players to plan this strategy effectively by understanding the comparative effects on the BMC.

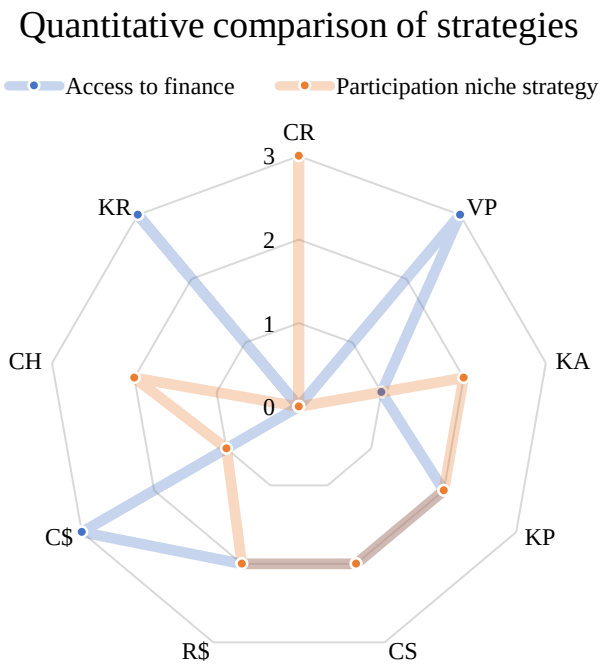


Figure 6-10 Quantitative comparison of strategies

4.2. Comparative analysis of strategies based on actual values of cost structure, revenue streams and customer segments to test financial viability

In the previous section, the quantitative analysis was performed based on a relative scale and not on actual values. In this section, a comparative analysis is performed for different strategies based on actual values of cost structure, revenue streams and customer segments. It is known from the strategy-BMC linkage that these three BMC elements (C$, R$ & CS) are affected with each strategy as discussed in *figure 5-2*. This analysis is important to understand the relationship between the cost incurred in implementing a strategy, the number of customer segments reached and the revenue generated from them. It is relevant to know from a business perspective that how much is the cost incurred and the amount of revenue generated to achieve net profit. The time period for the strategy to deliver results can be assumed. *Figure 6-12* illustrates a hypothetical case as the exact values were not known to compare the strategies. In *strategy 1* the revenues are higher than the cost incurred and the increase in customer segments in also known. Whereas in *strategy 3*, the customer segments drop relative to *strategy 1*, the cost incurred is higher as compared to revenues generated which shows the strategy is *NOT* profitable in monetary terms. This tool gives the market players an opportunity to understand the strategies in monetary terms and make strategic decisions for their companies. This tool compliments the understanding level of the strategy-BMC linkage matrix. However, the implications on other BMC elements must be kept in mind while working with this tool. The future researchers can explore this angle to develop an understanding of the strategies in actual monetary terms and its financial viability.

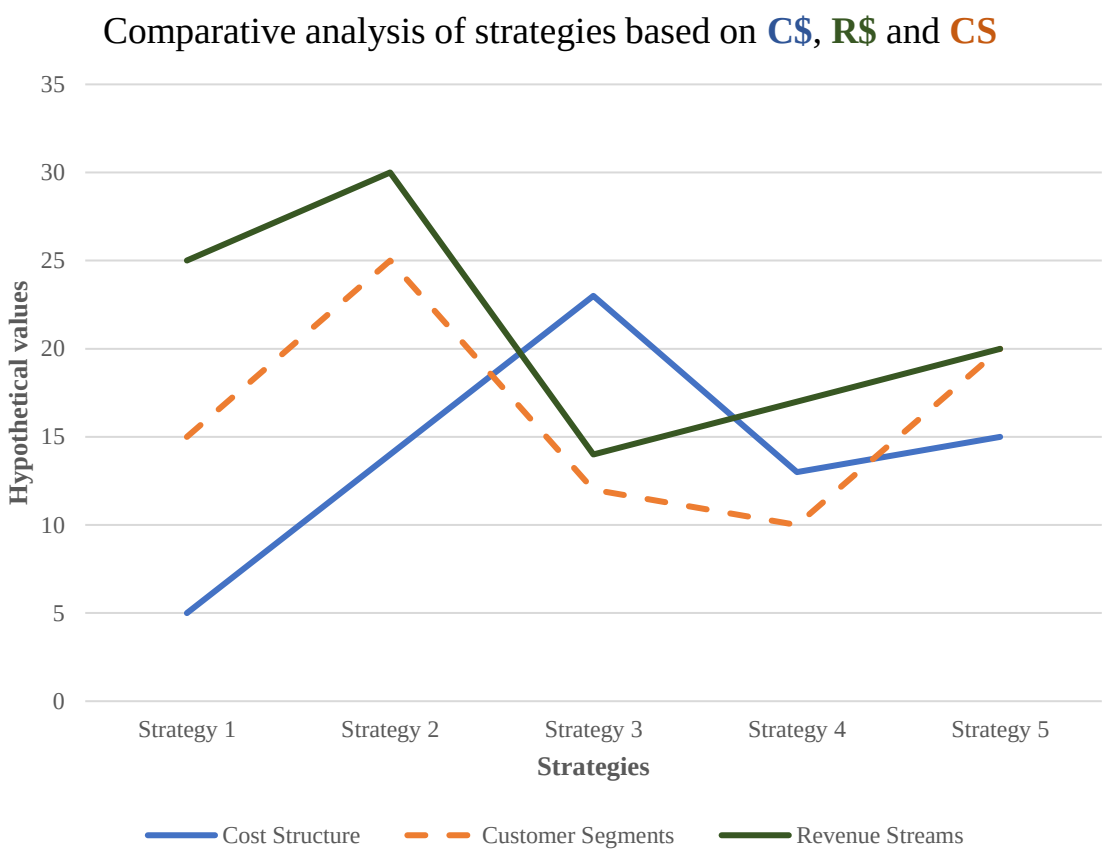


Figure 6-11 Comparative analysis of strategies based on C$, R$, CS

4.3. Quantitative comparison of strategies in cross-case analysis

Multiple strategies are identified and analyzed for different companies in the case studies. These strategies are implemented in various forms and have similar or different implications on their respective business model canvases. Similar strategies can be analyzed for the case studies performed and results can be obtained to understand the effects on a comparative scale. In *figure 6-13*, the ***hybridization or adaptor niche strategy*** is compared for Simpa Networks and Rural Spark. The illustration gives a clear idea on varying degree of implications of the strategy for two different cases. The practical usability of this comparison is to gain competitor analysis for two different companies. The values are assigned to the elements by the author based on data inferred from case studies, field visit and observations. The value proposition is strengthened *very strongly* by this strategy for Rural Spark whereas this strategy does not have any implication for Simpa Networks. The channels are built for both the companies but for Rural Spark, it is the most important route to deliver their value proposition whereas for Simpa Networks, it is a secondary route to reach the consumer segments. The customer relationship is built but not directly with the focal company rather through distribution partners who are also the key partners. Also, these key partners are most important for Rural Spark as their value proposition surrounds them whereas the key partners for Simpa are important but relatively on a lower scale. Finding and managing these key partners is crucial for Rural Spark which on a comparative scale is relatively higher than Simpa Networks. There is no implication on key resources as this strategy focuses on key partners. The effect on cost structure is similar as certain costs are incurred in building a network of distributors. This quantitative analysis on a comparative scale for different companies can be further explored for future research for all relevant strategies.

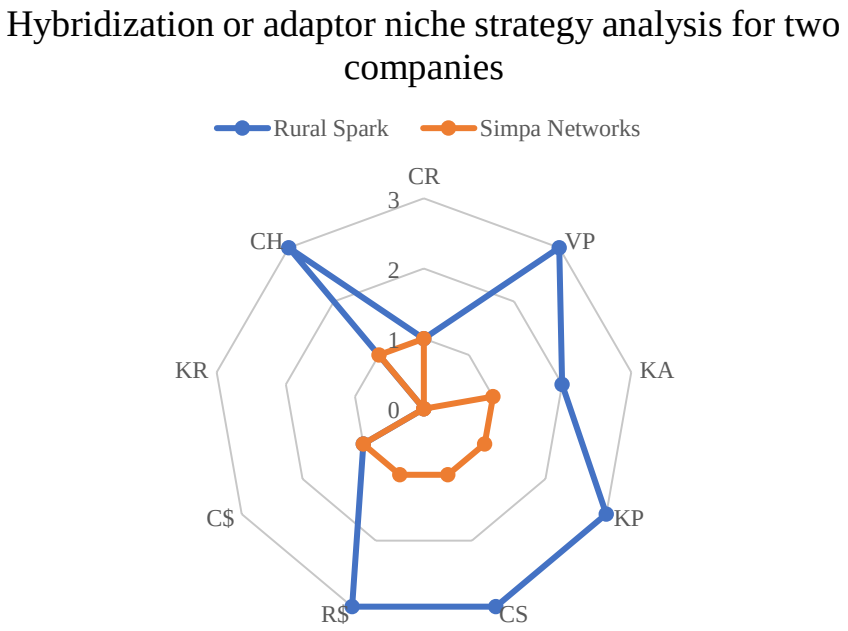


Figure 6-12 Strategy analysis for two companies on a comparative scale

4. Building a comprehensive business model

There lies another dimension to the linkages between strategies and the BMC elements which is to build a comprehensive business model. A business model can be created once the strategies are identified and their effects are analyzed on the BMC elements. Considering the possible implications, each BMC element can be constructed broadly leading to formation of a business model. For instance, the effects of access to finance strategy are known which has a *very strong* implication on the value proposition, cost structure and key resources. The service and maintenance strategy also has a very strong effect on the value proposition, cost structure and customer relationship. Now, knowing that the value proposition is affected very strongly by these strategies, this element can be constructed or reconstructed in order to give a well-defined meaning. The ***value proposition*** should now consist of access to finance options with proper service and maintenance provided to the consumer. The other implications can also be taken into account not just the *very strong* implications. Repeating this process for all the BMC elements, a refined and enriched business model can be created. This method is similar to enriching the strategy definitions using the BMC elements whereas here the BMC elements are defined using the strategies to create a business model. The effect of strategies on value proposition (VP) is illustrated in *figure 6-14* which then be further derived for a generic BMC element.

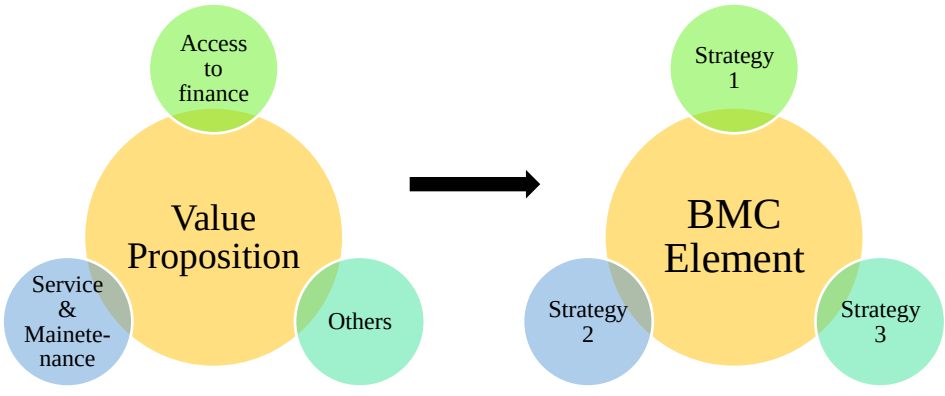


Figure 6-13 Defining a BMC element with the help of strategies

6.2.2. Contributions to Ortt *et al.* theory

The Ortt's framework consists of core and influencing factors which are adapted in this research project. In *table 6-4*, a list of influencing factors in the original framework are compared to the influencing factors in the adapted framework. *Figure 6-15* illustrates the factors categorized under different levels of adaptation. This adaptations framework was derived from (Berg 2017).

Level 5 Completely new factor	**Level 4 New factor within existing generic factor**	**Level 3 Factor is redefined**	**Level 2 Factor description changes**	**Level 1 Sub-element of the factor is more important**
Affordability Infrastructure Environmental Political Consumer awareness Financial Business knowledge Market competition		Suppliers	Production system Natural resources & skilled personnel Socio-cultural aspects Complimentary products & services Institutional aspects	New high-tech product

Figure 6-14 Factors categorized under adaptation levels

In the original framework, six influencing factors are present, whereas in the adapted framework certain factors are adapted and five new factors are added. The ***knowledge of technology*** and ***knowledge of application*** factors do not change and remain the same as in the original framework because its description in various literature sources is similar even for developing nations. The ***natural resources*** description is slightly adapted with the inclusion of "skilled personnel" in the description as it is relevant to this project as key resources of the focal company. The sub-element 'skilled personnel' is missing in the original framework rather it considers labor as one of the sub-elements which does not include the *skilled* nature. This factor is adapted under level 2. The ***socio-cultural aspects*** description is elaborated and described in different forms as mentioned in *table 6-4*. The credit risk and collection concerns add value to its definition. There are several other factors which are electricity theft, family dynamics and low education which enhances the description. Another aspect of the socio-cultural factor is the lack of stakeholder involvement. It acts as a barrier for the diffusion of this technology as the local community people are generally hesitant to adopt the technology. This was even confirmed via expert interviews and that it is indeed important to involve local people in the decision making such that it does not create a barrier for the diffusion process. In the original framework, this factor has a very generalized meaning describing norms and values whereas in this study, the meaning has been elaborated. This factor is split into multiple sub-factors based on the literature study, expert interviews and field study. These sub-factors are not present in original framework because of the nature of the factors which are only present in developing countries. This also comes under adaptation level 2. The ***macro-economic aspects and accident or events*** description do not change and is same as in the original framework.

There are five additional new factors which are added to the list of influencing factors. ***Affordability*** is one of the five new influencing factors which have been added to the Ortt *et al.* framework. Un-affordability is one of the foremost challenges in developing countries which reduces the number of customers. Due to low incomes, the customer is unable to purchase the product and due to the high significance of this factor, it is added as a completely new factor. In the original framework, under the factor *customers*, it is mentioned briefly if the customer is not able to pay for the technology but that is one of the main reasons why the customer segments do not exist in this market and hence needs extra attention. Therefore, this factor is categorized as a completely new influencing factor.

The next is lack of ***infrastructure*** which is poor road network that makes accessibility to the rural households difficult. The lack of infrastructure such as roads is identified as a key barrier from the literature study & case studies and observed during the customer visits made in the rural parts of India. This factor is missing in the original framework because the framework is designed for developed countries which do not face such barriers as they have an excellent road and communication infrastructure. This is a completely new factor and has been stressed by numerous stakeholders during the interviews and field study. The ***environmental*** factor is related to local pollution and ecological issues. This factor is absent in the original framework as the government in developed countries have stringent regulations on the production, development and dispersion of the end product (OECD 2016). The ***political*** factor comes with lack of political commitment and widespread corruption. The political factor did not reflect in the Ortt *et al.* framework as the corruption perception index (CPI) of developed countries is very high compared to the developing countries (Transparency International 2016). However, these factors did not come up in the case study interviews but were mentioned in many literature sources. Hence, to ensure wholeness of the adapted framework, they are introduced as completely new factors. ***Lack of business knowledge*** and skills and the unavailability of successful business models hamper the market growth. Solar home systems and its implementation is a radical technology to provide electricity to the rural areas. Consequently, there is a lack of successful business models and business knowledge which impedes the diffusion process. Therefore, it is necessary to include this factor in the original framework.

Table 6-4 Influencing factors in original and adapted framework

Original framework	Adapted framework
Knowledge of technology	Knowledge of technology
Knowledge of application	Knowledge of application
Natural resources • Lack of natural resources and labor	Natural resources • Lack of natural resources and labor • Lack of skilled personnel
Socio-cultural aspects • Norms and values	Socio-cultural aspects • No link to societal structure, norms and values • Credit risk and collection concerns • Low education • Payment default and product tampering • Risk of loot/theft • Electricity theft • Family dynamics in decision making • Lack of stakeholder involvement and local communities in decision making
Macroeconomic aspects	Macroeconomic aspects
Accidents or events	Accidents or events
	Affordability • Lack of paying capacity
	Infrastructure • Lack of road infrastructure
	Environmental • Local pollution and ecological issues
	Political • Lack of political commitment and widespread corruption
	Business knowledge • Lack of successful business models and business knowledge

Similarly, the core factors in the original framework are compared to the core factors in the adapted framework in *table 6-5*. The adapted framework in addition to the six original factors consists of three additional factors which are *consumer awareness and risk perception, lack of financial resources* and *market competition.* In the existing six core factors in the original framework, certain factors are adapted and three new factors are added to the new framework. The original framework is based on the diffusion of hi-tech products in developed countries and does not fit for the diffusion of technology products for developing countries, moreover in the rural areas. The first core factor which is the ***New High-tech product*** is slightly adapted with its description changed where the sub-element of this factor which is the high capital cost is most important. Hence, it is adapted under level 1 according to the adaptation levels. The sub-element *'High capital cost'* is highlighted in this factor as it is one of the most important barriers for this market as it hinders the end customers to buy the product and is indicated in the literature study, case studies and observed during the field work.

The next factor is adapted slightly with the inclusion of operation and maintenance facilities in the ***production system***. Hence this comes under level 2 of adaptation. Ortt *et al.* might have incorporated the *'lack of O&M facilities'* factor within the production system, but it should be split to gain more clarity within the factor. The availability of O&M facilities is necessary for a market where the end customer can have technical difficulties using the product. The description of the next factor which is ***complementary products and services*** is elaborated and made more specific and clear in the adapted framework. This factor in the original framework is very generic and implicit where the products and services are not specified. In the adapted framework, this factor is made explicit according to the market scenarios of a developing country like India. This is adapted under level 2 where the factor description changes. The factor was split into five key aspects which are *underdeveloped supply channels, lack of after sales services, lack of established dealer network, lack of technical support for installation and maintenance and spare parts* and *PV module availability.* The factor is split based on the literature & case studies and field work analysis to make it more specific according to the solar home systems market for rural electrification in the Indian market.

The factor *"**Suppliers**"* is redefined as the manufacturers and vendors of raw material and spare parts who act as key partners of the focal company. This is a more explanatory definition which was earlier very generic in the original framework. This adaptation comes under level 3 where the factor is redefined. The definition in the adapted framework is easier to understand as it clearly suggests who are the suppliers in a business ecosystem. With reference to this project, the main suppliers are for charge controllers, batteries and PV panels.

The ***Institutional aspects*** factor is described elaborately in this project and is made specific according to the diffusion of solar home systems in the Indian market. This also comes under level 2 of the adaptation as the factor description changes. Here, the rapid electrification policies and increased reliability of the mains grid are the most important factors to be considered which came up during the field study. These sub-factors are currently very critical and are the foremost challenges in the industry.

Next, three completely new factors are added to the core list of the original framework which are consumer awareness, financial and market competition and come under level 5 of adaptation. ***Lack of consumer awareness*** and misperceptions on the low-quality product acts as a barrier for the company. This barrier is defined explicitly in literature and also came up in the expert interviews. Lack of consumer awareness is briefly mentioned in the original framework under the factor *customers*. This barrier was observed during the customer visits made in India and also came up multiple times during the expert interviews. It is certainly necessary to have a separate factor because of its significance level. Therefore, it is added as an additional factor in the core list of the original framework.

The next barrier is the ***lack of financial resources*** both for the consumer and the company. Lack of financing mechanisms blocks the consumer to buy the product as un-affordability and high cost are major bottlenecks. The lack of access to capital for companies is quite challenging in the Indian market.

This is an important aspect for the companies as the working capital is quite essential for them to perform their key activities. This factor is highly important as indicated by the experts, the field staff team and the local stakeholders. This factor is missing in the original framework as the financial systems are well defined in the developed countries and on the other hand are not matured enough in developing countries. Another reason is because of the novel nature of the technology, the financial institutions do not trust this sector and hence the financial instruments are missing. This factor is added to the core list of factors and is split into lack of financial instruments for customers and companies.

The last factor added to core factors list is the presence of severe ***market competition*** which has disrupted the market. The sale of low cost and low-quality products offers a major barrier to the diffusion of genuine high-quality products. Market competition is emphasized by various experts, local stakeholders and key partners of the company. This factor comes when the technology starts to enter the *stabilization phase* where numerous companies begin to enter the market. This factor was missing in the Ortt *et al.* framework as the framework focuses on the *adaptation phase* and *NOT* on the *stabilization phase*. The adaptation and stabilization phases are explained by Ortt *et al.* in a life cycle model of radically new high-tech products described in *figure 6-15*.

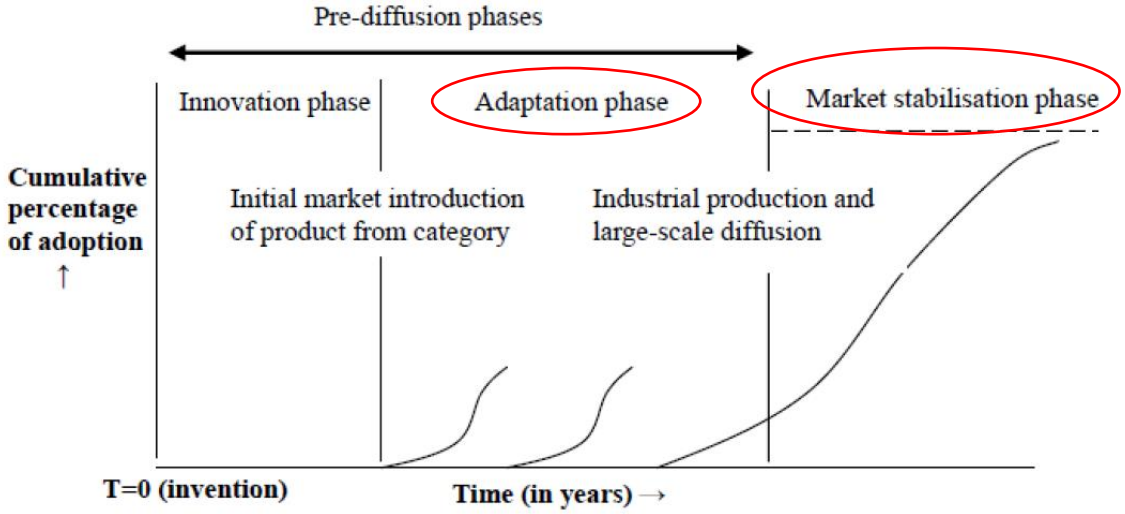


Figure 6-15 Product development phases on a time axis

Table 6-5 Core factors in original and adapted framework

Original framework	Adapted framework
New high-tech product • Technological principle • Product unavailability • Good price/quality	New high-tech product • **High capital cost** • limited product availability • product unreliability
Production system • Unavailability of a good production system	Production system • Lack of a good production facility • Lack of O&M facilities
Complimentary products & services • Lack of products and services for production, adoption, distribution and use	Complimentary products & services • Underdeveloped supply channels • Lack of after sales services • Lack of established dealer network • Lack of technical support for installation and maintenance • Spare parts and PV module availability
Suppliers (network of organizations) • Producers and suppliers involved in supply of the product	Suppliers (manufacturers and vendors of raw material, spare parts) • Lack of excellent market support infrastructure • Delay in supply of products
Customers • Lack of customers • Applications are unknown • Unaware of the benefits	Customers • Limited markets • Small market size • Lack of consumer acceptance • Uncertain demand • Lack of established market
Institutional aspects (laws, rules & standards) • Stimulation or blocking of the product applications	Institutional aspects (laws, rules & standards) • Lack of adequate government policies • lack of institutional capacity • lack of information to companies on market scenario • stiff competition from conventional energy, unstable policy • high import duties • Rapid electrification policy and increased reliability of mains grid
	Consumer awareness & risk perception • Lack of consumer awareness • high-risk perceptions • misperceptions on low quality products
	Financial • Lack of financing mechanisms for consumers • lack of access to capital for companies • high cost of innovation • high investment • lack of business financing and skills
	Market competition • Competition from the market players selling products at lower prices

The strategies in the original framework are also compared to the strategies in the adapted framework. Five strategies are added to this framework which are access to finance, lobbying, participation niche strategy, environmental measures and service & maintenance. These new strategies are highlighted in color blue. In *table 6-6*, the strategies in the original framework and adapted framework are compared. The original framework has ten niche strategies whereas the adapted framework has five additional strategies and the original ones are slightly modified.

The ***demo, experiment & develop niche strategy*** is highly relevant and consistent in definition as extensive research & development and pilot projects are required for development and testing of the technology. The ***top niche strategy*** is essential as the technology can be first introduced with the affluent customer base and then gradually diffusing into the remaining segments. In addition to these strategies, the redesign niche strategy, dedicated system or standalone niche strategy, geographic niche strategy, lead user niche strategy and explore multiple markets niche strategy are NOT adapted in the new framework as they fit into the current scope of research.

The ***subsidized niche strategy*** is *absorbed under* ***access to finance strategy*** which is split into two categories namely end consumer finance and financing for companies. The subsidized niche strategy is a sub-strategy here where subsidy is introduced on the product and is offered for a lesser price. The other elements of the access to finance strategy are financing the consumers through rural/mainstream banks, microfinancing options and financing the company through debt/equity capital, investment through development institutions, off-balance sheet financing and others. This is a vital strategy as the financial barriers are strong in the developing countries and due to the novel nature of this technology, these institutions lack trust and do not want to take the risk.

In the ***hybridization or adaptor niche strategy***, the role of finding existing distributors is important to reach the consumer base and has been *highlighted* in *table 6-6* In the original framework, the role of complimentary products and services was very generic as discussed earlier in this section. In the adapted framework, the focus of this strategy is on finding and leveraging the network of existing distributors where they act as additional channels for distribution. In the ***educate niche strategy***, it is extremely important to educate the consumers and company employees as *highlighted* in *table 6-6*. In the original framework, the educate niche strategy is aimed towards educating only suppliers and customers whereas in the adapted strategy, the employees are also educated and trained. The employees are the face of the company and should have relevant skillsets and knowledge about the technology.

The ***participation niche strategy*** focuses on the role of village level entrepreneurs, social & community workers and self-help groups to promote the product, educate the customer and build relationship with them. The role of village level entrepreneurs was observed closely during the field visit and was strongly supported by the sales and service team of the focal company. This strategy could be an extension to the top and lead user niche strategy where the top and lead users are given the onus to promote the product, educate the customers and build trust and relationship with them. Hence, this addition is necessary as a completely new strategy to the original Ortt *et al.* framework.

Lobbying and environmental measures were identified in the literature study but did not come up in the case study interviews and field work. Nevertheless, they are introduced in the adapted framework in order to ensure its completeness. The environmental measures are not incorporated in the original Ortt *et al.* framework which might be because of the high standards of production in the developed countries such that they do not have any implications on the environment. The ***service and maintenance strategy*** is vital to ensure quality of the product and build trust within the customer. The Ortt *et al.* framework focuses on strategies for selling and diffusion of the product but does not focus on strategies which are relevant after the sale of the product. The service and maintenance is introduced once the product is sold to the end customer. The market players are introducing this strategy actively and has also become a part of their value proposition. Hence, this strategy is another addition to the list of niche strategies in the original framework.

Table 6-6 Niche strategies in original and adapted framework

Original framework	Adapted framework
Demo, experiment & develop niche strategy	Demo, experiment & develop niche strategy
Top niche strategy	Top niche strategy
Subsidized niche strategy	*--Absorbed under Access to finance--*
Redesign niche strategy	Redesign niche strategy
Dedicated system or standalone niche strategy	Dedicated system or standalone niche strategy
Hybridization or adaptor niche strategy	Hybridization or adaptor niche strategy
Use of complimentary products and services of the old product	*Finding existing distributing partners*
Educate niche strategy	Educate niche strategy
Customers and suppliers	*End consumers, suppliers & employees*
Geographic niche strategy	Geographic niche strategy
Lead user niche strategy	Lead user niche strategy
Explore multiple markets niche strategy	Explore multiple markets niche strategy
	Access to finance
	End Consumer finance / *Finance for companies*
	Lobbying
	Participation niche strategy
	Village level entrepreneurs / *Social and community workers* / *Self-help groups*
	Environmental measures
	Service & maintenance

6.2.3. Barriers dynamics and linkage with BMC

The three case studies, expert interviews and field study in rural parts of India helped in identifying numerous barriers and strategies. With the implementation of certain strategies, barriers are circumvented but give rise to additional barriers which require different set of strategies. This dynamic nature is critically analyzed for some barriers and discussed below.

The level of consumer awareness for the solar technology has increased compared to the past decade and is continuously improving. However, majority of the population is still unaware of the technology and its applications despite strong efforts by the market players. Nevertheless, with increased awareness activities, the ***customer segments*** are increasing. The companies are investing in different kinds of awareness activities such as marketing campaigns, canopy and door to door activities which requires working capital and additional employees which form the ***key resources*** for the company. This gives rise to barriers such as additional capital requirement and finding skilled employees for the marketing and awareness programs.

The distribution network was not developed initially but with the growing demand the companies are increasing their workforce in terms of sales and service agents. However, finding skilled talent is again a challenge for the company which is overcome by education and training programs. Also, the existing distribution network is also being leveraged now to sell the solar home systems. The distribution and service network is still under-developed but has improved significantly in the past five years. It has resulted in increased ***channels*** and ***key partners*** for the company thereby increasing the ***customer segments*** and ***revenue streams***. The key partners in the form of distributors to the focal company face barriers such as intense market competition due to which the sale of their products has declined.

The financial barriers were quite strong in the last few years but now the situation is adapting. People are getting access to financing schemes and companies are obtaining working capital and investments from a wide source of investors. The strategies are also focused to obtain funding from the mainstream banks. Though it is a challenging task to convince these banks for funding in this sector which they presume to be quite risky. With the implementation of this strategy, ***key partners*** are developed and the ***value proposition*** is strengthened with the inclusion of financing opportunities for customers.

The price of the solar home systems has reduced drastically in last ten years majorly in the PV module cost which has brought down the overall cost of the system (Feldman *et al.* 2012). Nevertheless, the current price is still unaffordable for most of the consumer segments but with continued research and development, it has a potential to reduce further reduce the price. This will increase the ***customer segments*** as a better ***value proposition*** is offered. To overcome the high cost barrier, financial schemes are being introduced for the customers as stated above so that they can purchase the product. In some cases, the customer is unable to pay the installments for the product and hence the product is uninstalled. This hampers the company's sales figures and results in losing out the customer and its ***revenue streams.***

Market competition was not prevalent when the technology was first introduced as only few players entered the market. Currently, there are numerous market players which have flooded the market with low quality products and have disrupted the market. Market competition is stronger currently and has reduced the ***customer segments*** for the focal company which has further implications on the ***revenue streams***.

The effect of socio-cultural norms and values reduces gradually with the diffusion of the technology. People gain trust in the product and company if proper service and maintenance is offered to them. With the diffusion of the technology, other socio-cultural barriers come up such as payment defaults and product tampering which require different kind of strategies. The onus lies on the service team to check for any payment default and product tampering. The ***key activities*** in the form of increased monitoring and building ***customer relationship*** are stepped up with this strategy.

6.2.4. Methodological contributions

This section describes the methodological contributions of this master thesis project. This section is divided into four categories which are *multistep detailed research framework, BMC aspect in the case study interviews, multiple stakeholder interviews* and *linkage of strategies with BMC.*

Multistep detailed research framework

A multistep detailed research framework was adopted to adapt the original Ortt *et al.* framework. In this research project, the focus is on the solar home systems technology for diffusion in the rural parts of India. Three steps for the literature study were performed as illustrated in *figure 6-17*. The first step in ***Stage 1*** of adaptation is finding generic barriers for diffusion of technologies in a developing country like India. In the second step of ***Stage 1***, the barriers and strategies are focused on renewable energy technologies in developing countries. Further, in the next step which is ***Stage 2*** of adaptation, the barriers and strategies are identified for the diffusion of solar home systems in developing countries like India & African countries. With this detailed framework, the barriers and strategies are identified to adapt the Ortt *et al.* framework and explore all possible barrier and strategy sets.

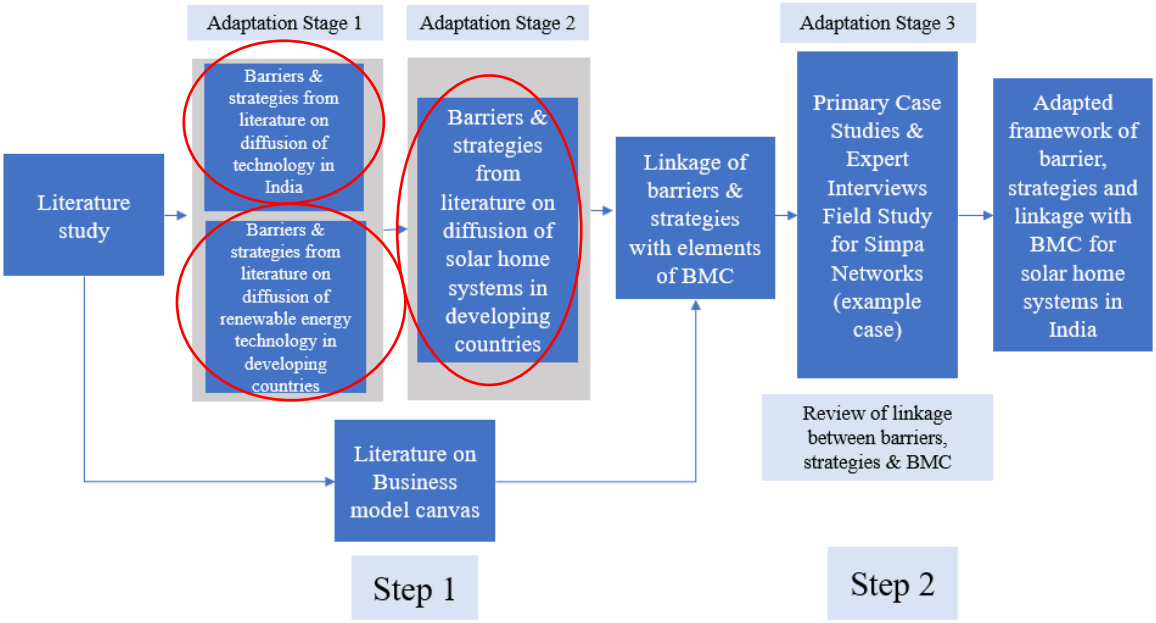


Figure 6-16 Multistep detailed research framework

BMC aspect in the case study interviews

During the case study interviews, in addition to open and closed questions on barriers and strategies, questions were asked based on the elements of the business model canvas. Questions were asked to identify each element of the business model canvas. This helped in building an all-inclusive business model canvas for each case study.

Multiple stakeholder interviews

Multiple stakeholder interviews were conducted during the field study in Uttar Pradesh, India. The stakeholders included sales team, service and operations team, credit team, distributors, supply chain team, end customers and village level entrepreneurs. These diverse interview sessions helped in critical analysis of the market in terms of barrier and strategy identification and its linkage with the elements of the BMC.

Linkage of strategies with BMC

The linkages of strategies with BMC were constructed after gathering information on barriers, strategies and BMC elements. The linkages are in the form of a matrix where the strategies are mapped to the respective BMC elements based on relevant implications. This matrix is important to develop the concept further to make it more qualitative and quantitative as discussed in ***section 6.2.1***.

6.2.5. Reflection & limitations of the research

In this section, the reflection and limitations of the project are discussed. This chapter essentially focusses on the limitations and reflections based on case study interviews, field study and strategy-BMC linkages.

Finding literature sources on the barriers and strategies for diffusion of renewable energy in developing countries was not really a limitation as ample amount of literature is available. The approach of first finding generic barriers and strategies from the Indian context and then focusing on the specific barrier-strategy sets for renewable energy systems and essentially solar home systems proved quite logical. The understanding of the barrier-strategy sets became quite simple with this method.

The biggest limitation of this work was to establish contacts with the relevant companies for the purpose of conducting expert interviews. It was extremely difficult and time consuming to achieve a conversation (through phone and email) with the stakeholders. Either there was no reply or if it was there, it was with a lot of delay and moreover showed no interest.

Also, even when the meeting was scheduled, in 45 minutes to one hour, it was not possible to get all the answers to the questionnaire. The questionnaire was quite lengthy for the stakeholders to answer. Therefore, during the interview, the questionnaire was slightly adapted to receive maximum answers. The questionnaire was sent prior to the interview so that the interviewee has an idea of what is expected out of the interview. However, it was clear from the interviews, the questionnaire was not given attention. For the closed questions to be answered where the interviewee was asked to rate the importance of barriers and strategies, the exercise was not successful because of time constraint.

The field study to India proved quite useful and successful. The credibility of the literature study and telephonic interviews increased by visiting the site operations and talking to customers. The idea of shadowing one of the field staff members for the customer visits was indeed quite helpful in conducting interviews and was time saving. However, due to extreme weather conditions and lack of access to personal transport, it was quite difficult to travel around places. It was quite hard to adjust to the sudden change in climatic conditions. The customers were located far off from each other; therefore, accessibility was a big concern.

The strategy-BMC matrix developed in the project does not include the level of importance of the linkages. It is extremely important to understand which strategy has a stronger or weaker implication on the BMC elements in order to critically analyze the strategy. Hence, this is an opportunity for future researchers to look into a qualitative and quantitative model which gives a detailed strategy-BMC linkage. This qualitative and quantitative analysis is briefly described in *section 6.2.1*.

The strategy-BMC linkage matrix is developed for solar home systems for rural electrification from an Indian perspective. The linkage is further explored in the discussion section where multiple types of analysis are possible. The practical usability of the matrix does not limit to only one technology or one region. This matrix can be developed for diverse business fields ranging from micro level business firms to large scale firms. For instance, in the food industry, both a small-scale food joint and fast food giant *McDonalds* can use this framework to develop strategy-BMC linkages for themselves and understand their business models in an explicit manner.

6.3. Recommendations

This section deals with the practical recommendations for the market players, theoretical recommendations for future research and recommendations for the product designers. The practical recommendations are based on the barriers faced and strategies employed by the companies to develop a successful business model. The academic recommendations deal with the topics for future research and research methodology. The recommendations for product designers focus on the areas for technology and product improvement.

6.3.1. Practical Recommendations

The practical recommendations largely focus on the sector players in the off-grid solar solutions market. The following barrier sets in *table 6-7* should be focused on. These are affordability & high cost, consumer awareness, lack of financial resources, socio-cultural aspects, complimentary products and services, institutional, market competition and lack of skilled personnel.

Table 6-7 Barrier recommendations

Barrier	Explanation
Affordability & high cost	This is extremely important in a place where people have very low incomes. The cost of the product is a deciding factor in these areas, hence requires deep focus.
Consumer Awareness	These places have very low education levels which results in low consumer awareness. People haven't open their minds towards solar technology.
Financial	The lack of financial resources for the consumer has created a major roadblock and restrains the consumer to buy the product. Working capital in the Indian market is kind of challenging and without that the company cannot survive.
Socio-cultural aspects	Adoption is one of the challenges. Revenue collection is a major concern as people are not used to pay for electricity.
Complimentary products & services	Distribution is a major challenge as to reach out to the customers is difficult. Finding distributing partners who have a good reach in the village is a tough task.
Institutional	The government plans to electrify the villages and increase in reliability is shrinking the market very fast and has created a main barrier in the sector.
Market competition	Market competition from local and Chinese products which are offered at a much lower price
Skilled personnel	Lack of skilled personnel for sales and operations can hamper the diffusion process.

The strategies identified from literature and case studies needs to be understood thoroughly and requires deep attention. Following niche strategies in *table 6-8* are the most important to sustain in the solar home systems market. These are access to finance, participation niche strategy, educate niche strategy, hybridization or adaptor niche strategy, demo, experiment & develop niche strategy and service & maintenance strategy.

Table 6-8 Strategy recommendations

Niche Strategy	Explanation
Access to finance (consumer)	Access to finance via micro-finance institutions, local banks, Self-help group finance is crucial for providing access to finance for consumers
Access to finance (company)	Access to finance via funding organizations and international donors should be given key importance for raising capital

Participation Niche Strategy	The participation of local heads or influential people of the villages is extremely important in convincing the consumers. These local heads can be appointed as the ambassadors of the company.
Educate Niche Strategy	To educate and create awareness among the consumers is an important part of the strategy set. This can be done my marketing activities and demonstrations activities in the village. Also, this can be done with the help of community workers, social organizations and self-help groups. Educating the employees about the product and company policies is extremely important.
Hybridization or adaptor Niche Strategy	This is the most important strategy to find an existing distributor base who have a good reach in the market. Finding existing distributors who are selling electrical goods, rural partners such as petrol stations, e-commerce providers, access to energy organizations have a good reach and customer base.
Demo, experiment & develop niche strategy	Developing the product keeping in mind the current aspirations of people and local conditions is extremely important. The product must be continuously upgraded according to the needs of the people. The product also needs to be grid compatible keeping in mind the rapid electrification process.
Service & Maintenance	To implement service and maintenance process which is key to after sales service. This can be done by deploying a service team or through partners

An important recommendation apart from these strategies is to create a knowledge platform where the companies and organizations operating in this sector should meet and discuss their experiences. These companies should share their barriers and strategies with each other to shape the market in a better way.

6.3.2. Academic Recommendations

The set of recommendations discussed in this section are important from an academic point of view. It deals with recommendations for future topics and recommendations on the methodology.

The current research focusses on limited number of articles and reports for literature study and three major case studies and few expert interviews which could be arranged in this span of time. Moreover, the research is done keeping in mind the Solar Home Systems and in a developing country like India. The product portfolio can be diversified in the future research projects and should not be limited to one region or country. The literature base and the case studies can also be expanded for precise results. The expert interviews add value to the project and hence must be introduced in a project.

For conducting interviews, all the existing contacts must be explored to approach the company executives. Cold calling does not prove to be quite successful as most of the emails goes unread. The interviewees must be approached well in advance for the interview sessions. Follow up emails are indeed important to keep a track on the interviewee. Detailed research about the company is quite useful for conducting the interviews. The introduction emails sent to the company must be customized for each company and the topic of research must be introduced. The questionnaire should be crisp and to the point. While conducting interviews, a voice recorder must be used after seeking permission from the interviewee. This is quite an essential tool to keep a track of things.

The field study for this project was quite beneficial and hence must be pursued in future projects. Field visit conducted in this project was limited to a few villages in India due to time constraint but for future projects, it must be carried out for a longer period of time. These visits can be made to different provinces or states to understand diverse socio-cultural barriers and should not be limited to only one region. These visits should be planned well in advance.

In the subsequent section, research questions for the future researchers are discussed briefly. These recommendations are primarily based on the strategy-BMC linkages.

1. *How can you enrich the strategy definitions using the elements of the business model canvas?*

As discussed in the previous sections, the relation between the business model canvas theory and theory on barriers and niche strategies can be identified in two ways. In the first representation, the BMC acts as an analysis tool to understand the effect of various niche strategies whereas in the second representation, the BMC elements add enrichment to the strategy definition. For the current research, the first method was used to study the linkage between strategies and BMC elements. The second method gives an opportunity to the future researchers to redefine the original strategies which are meagre and implicit in nature. With this method by using elements of the BMC, the strategies are expressed explicitly with enriched meanings. For instance, any strategy can be redefined using the nine elements of the business model canvas as elaborated in the discussion section for *hybridization or adaptor and participation niche strategy*. The hybridization or adaptor niche strategy is redefined in the following way:

The hybridization or adaptor niche strategy can be adopted where the existing distributors who have an established customer base act as additional distributing CHANNELS of the company to reach out to the CUSTOMER SEGMENTS in order to deliver a VALUE PROPOSITION. These distributing channels are essentially identified as KEY PARTNERS of the company. In building these distributing partners, certain costs are incurred which contribute to the COST STRUCTURE of the company.

2. *How can the effect of barriers faced and strategies employed by the key partners to the focal company be understood on the focal company's business model canvas?*

The field visit added an important aspect and opened a discussion regarding the barriers faced and strategies employed by the ***key partners*** to the focal company. These key partners are the distributors, village level entrepreneurs, financial partners and suppliers etc. The implications of these barriers and strategies on the focal company's BMC can be analyzed in detail to understand how the focal business model is affected by their key partner's activities. In this discussion section, the barriers faced by the distributors is taken up and the effects of these barriers on the BMC is analyzed. These barriers are lack of awareness among customers, high market competition and service & maintenance of the products. There are other key partners such as financing agencies, mainstream banks and suppliers which could not be interviewed due to time constraint but their insights are certainly helpful in further developing this argument. Key partners play a pivotal role in a company's business model by performing diverse set of functions such as finance, distribution and production. Thus, it is imperative to understand the barriers faced and strategies employed by these partners and their implications on the focal company's business model.

3. *What are the qualitative effects of the strategy-BMC linkages obtained in the thesis project?*

The strategy-BMC linkage matrix can be made qualitative by adding a degree of importance to the implications as argued in the discussion section. The strategy-BMC linkages can be categorized into four levels *no implication, implication, strong implication* and *very strong implication.* The matrix can now be understood effectively with a degree of implication on the strategies. For instance, the access to finance strategy has a very strong implication on the *value proposition, cost structure* and *key resources* and a strong implication on *key partners, customer segments and revenue streams*. The strategy has an implication on *key activities* and no implication on *customer relationship* and *channels*. In this way, now it is possible to categorize the strength of the implications which was earlier not possible in the matrix. The future researchers can explore this perspective on the qualitative strategy-BMC linkages.

4. *What are the quantitative effects of the strategy-BMC linkages obtained in the thesis project?*

The strategy-BMC linkages can be made quantitative by assigning a numeric value to the qualitative matrix as shown in the discussion section. No implication is assigned the value 0, implication is assigned 1, strong implication is assigned 2 and very strong implication is assigned 3. In this way, the

implications of each strategy can be plotted on a radar chart and the effect can be understood quantitatively. This method to understand the implications where a numeric value is assigned to each implication enhances the analysis. This can also be used to compare two or more strategies and its effects on the business model canvas. The strategies can be compared on actual values of cost structure, revenue streams and consumer segments to understand the financial viability of the strategy. Also, a comparative analysis for a strategy can be performed for different companies to understand the implications on a common scale. The interviewers can be asked to rate the strategy-BMC implications on a numerical scale to attain an evidence based quantitative analysis.

5. *How can you build a comprehensive business model using the strategy-BMC linkages?*

A comprehensive business model can be built using the implications of strategies on the business model elements. This is similar to enriching the strategy definition using the BMC elements. Here, the BMC elements are enriched by using the implications of the strategies. For instance, to enrich or build the ***value proposition*** element, let us consider the *very strong* implications on it. *Access to finance* and *service & maintenance* strategies have a very strong implication on the value proposition. Hence, ***VP*** can be formed or enriched by using these implications. ***VP*** should now contain access to finance options and service and maintenance elements. Similarly, other elements of the BMC can be formed using the same methodology. Here, only very strong implications have been considered but the future researcher should also consider all degrees of implications in framing the business model.

6. *How can we maximize the diffusion of **renewable energy products for the BoP market in developing nations** using the linkage of barriers and strategies with the business model canvas?*

The barrier and niche strategy sets are currently studied for a very specific technology in a developing country like India. There can be several spin-off research topics from here. First, keeping the future research for a specific technology, it can be expanded to other base of pyramid regions such as African countries or other less developed nations. This can increase the usability of the framework. Secondly, for a specific location, different renewable technologies can be considered and barrier-strategies sets can be explored. This will again increase the usability of the framework. Finally, the generic framework can be produced keeping in mind various renewable energy technologies in different regions. The framework developed can be further linked to business model theories to enhance the scope of research.

6.3.3. Recommendations for the product (SHS) designer

This section focusses on the recommendations for the product designers which are developed based on the expert interviews and case studies. These recommendations are important while designing the product and gives an updated view of the market scenario.

1. *To design the product keeping in mind the current aspirations of people and their growing lifestyle*

The demands of the people grow with time and their changing lifestyle. They need upgraded systems which can run additional appliances both DC & AC. This is an opportunity for product designers to study the needs and demands of people in developing the product. Providing few light sources, a fan and a TV is not enough for the people today, they want to use a refrigerator, an iron, a music system etc. Hence it is necessary to understand these demands and develop a product which meet the needs of the people.

2. *To design the product considering the rapid grid expansion and its increased reliability. This can be done by making the products grid compatible*

It was observed during the field visit and expert interviews that the national electricity grid is extending rapidly and with improved reliability. This poses a challenge for companies selling off-grid products in the rural areas without electricity. The central grid is getting upgraded hence the off-grid products also need to be upgraded. This can be done in the form of making the products grid compatible thereby making a hybrid system. In that case, the batteries in the solar home system can be charged both with the PV panel and electricity grid.

3. To make the products tamper proof

A key barrier which was identified during the field visit is the tampering of products by consumers which are provided to them by the company. The consumers bypass the metering technology such that they do not have to pay for the services provided by the company. This is a feedback for the product designers to make products which cannot be tampered with and which can remotely monitor and communicate with a central system in case of any such tampering activity. The onus lies with the product designer or the implementing agency to responsibly control the monitoring technology.

Remote monitoring can have ethical considerations on the implementing agency as it monitors and collect load & battery information from each household. In this way, it has access to the personal data and therefore, has a moral responsibility for handling that information.

4. To look for interconnecting the solar home systems to form a micro-grid

A key aspect for the product designers could be to interconnect the solar home systems with an aim of load sharing. The systems can communicate with each other and share load at the same time. Trade of electricity is possible between with fellow villagers. The existing electricity distribution grid can be leveraged and used to interconnect the SHS making it a smart micro-grid. This network works on the principle where if one of the villagers have a high load demand, one can buy excess electricity from the fellow villagers who have a low demand at the same time. This way, optimal use of electricity can be achieved and load demands can be met which were not possible with the existing individual system.

5. To consider the efficacy of the LED lights and look for possible improvements

During one of the expert interviews, the potential improvement in the efficacy of LED lights was discussed. The efficacy of any light sources is defined as lumens/watt. With the increase in efficacy of light source, the battery size can be brought down which lowers the overall cost of the system. However, the increased efficacy leads to a limited reduction in the overall cost but is an important observation to look upon.

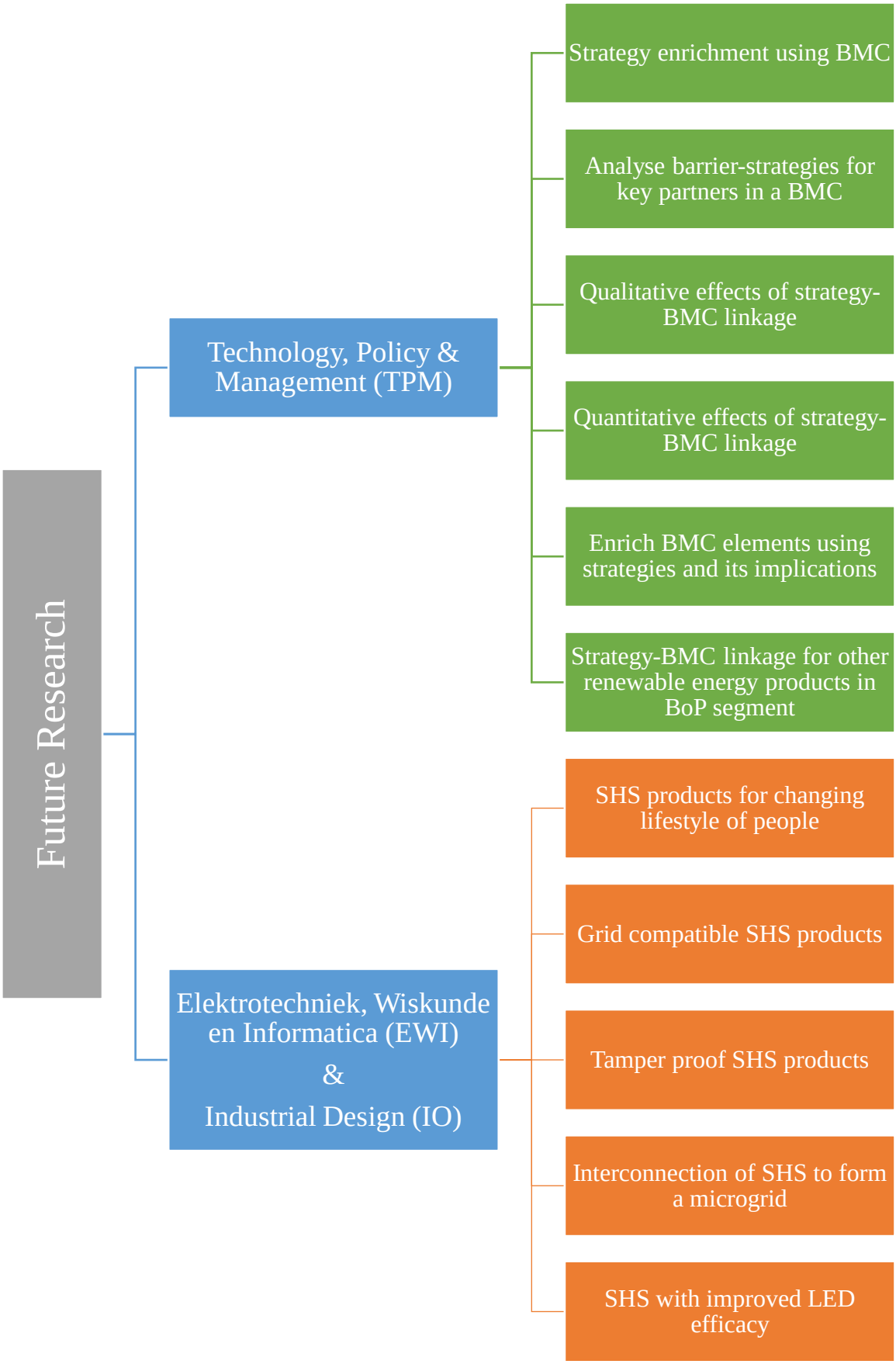
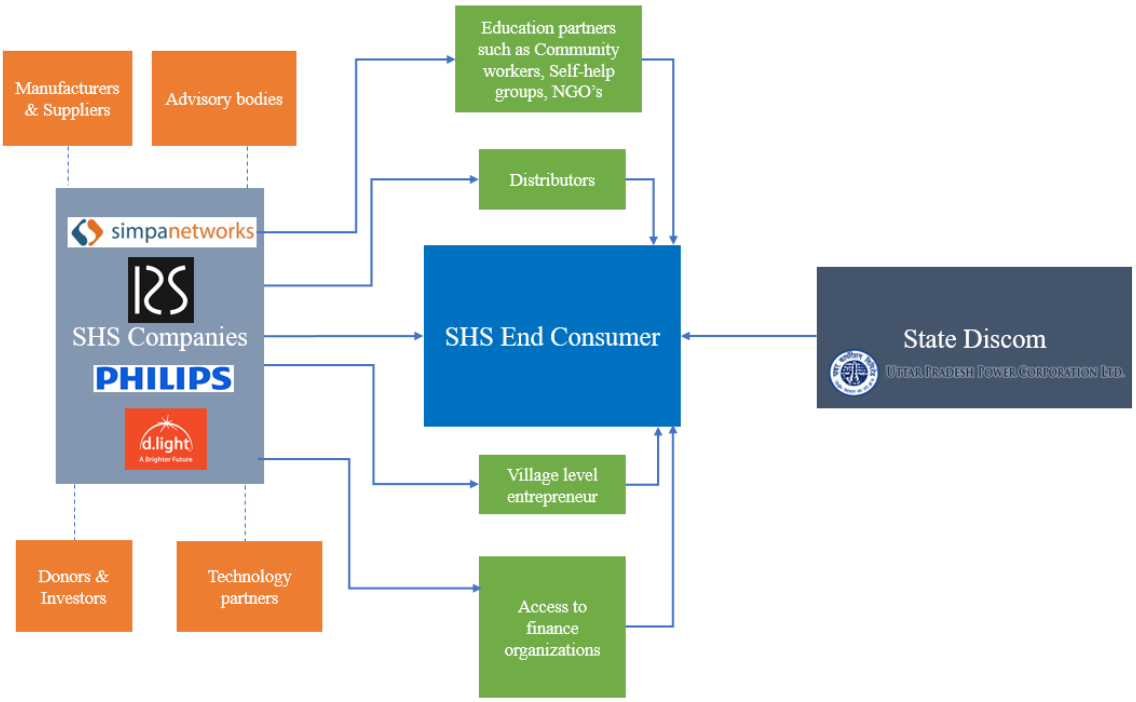


Figure 6-17 Future research topics categorized by faculties

Appendix A

Stakeholder map for SHS market in India

The stakeholder map revolves around the end consumer. The end consumer is connected to the company in multiple ways. The focal companies in this project are based out of the solar home systems market. Few examples include Simpa Networks, Rural Spark, Philips, D.light and several others. The end consumer is directly connected to the focal company and its key partners. These key partners are distributors, education partners such as community workers, self-help groups and NGO's, village level entrepreneurs such as local heads, influential person in a village, local shopkeeper or a teacher and access to finance organizations such as micro-finance institutes and local banks. The focal company has another set of key partners who are not connected to the end consumer. These are company's manufacturers and suppliers, advisory bodies, donors & investors and technology partners such as research institutes and universities. The end consumer is connected to the state electricity distributing company if the consumer is connected to the main grid.



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Appendix C

Background notes for interviewees

Providing electricity to all is a key challenge which the world faces today particularly in the developing nations. In today's world, the concern for climate change is growing rapidly and consequently, the use of renewable energy has become inevitable. Solar energy has become an efficient and financially viable solution to provide access to electricity to the under-developed and developing nations in the recent times. However, during the implementation, it faces certain barriers such as technical, economic, institutional, socio-cultural and environmental. These barriers hamper the diffusion of renewable energy and dampen the rate of electrification particularly in developing countries. The main research question to be answered in this project is "How can we maximize successful penetration of solar home systems for rural electrification?". The primary deliverable of this project is a framework to study the barriers and strategies for successful diffusion of solar home systems in the Indian market and the linkage between the business model canvas with an adapted framework from literature. The project has high societal relevance thereby solving the socio-economic crisis of the rural populace and steering them towards a better future.

Objective and approach of this interview

The objective of this interview is to gain insights on various barriers and strategies for the diffusion of solar home systems in developing countries for rural electrification. Another objective is to validate our adapted framework on linkage of various market situations with elements of the business model canvas. To this purpose, we would like to go through various barriers and strategies one by one and then move onto the linkage part. We also present a list of barriers that came up in our literature study (See Annexure). The detailed list of topics to be covered in this interview are presented below:

Topics - Open

1. **What type of systems the company deals with? (SHS, micro-grids, utility scale)**
2. **What are the various locations of your project activity?**
3. **What is your key target group and why?**
4. **Which are the most important barriers that your company has faced? (mention at least 5)**

Closed

5. **Is there any important barrier which we missed in our literature study? Could you also rank these barriers on a scale of 0-7 where 7 is most important?**

Open

6. **What are the various measures that your company took in overcoming these barriers?**
7. **How does your business model look like in terms of the business model canvas?**
8. **What implication does these strategies have on the nine elements of the business model canvas? *(List of nine elements of business model canvas provided)***

Closed

9. **How important are the strategies listed in our literature study? Could you also rank these strategies on a scale of 0-7 where 7 is most important?**

Open

10. **What other strategies would you suggest for companies venturing into SHS market?**
11. **What would be your closing remarks for successful diffusion of solar home systems for rural electrification?**
12. **Would you like to recommend someone for a similar interview?**

References

Akikur, R.K. et al., 2013. Comparative study of stand-alone and hybrid solar energy systems suitable for off-grid rural electri fi cation : A review. *Renewable and Sustainable Energy Reviews*, 27, pp.738–752. Available at: http://dx.doi.org/10.1016/j.rser.2013.06.043.

Anderson, J. & Billou, N., 2007. Serving the world's poor: innovation at the base of the economic pyramid. *Journal of Business Strategy*, 28(2), pp.14–21. Available at: http://www.emeraldinsight.com/doi/abs/10.1108/02756660710732611.

Barman, M. et al., 2017. Energy for Sustainable Development Performance and impact evaluation of solar home lighting systems on the rural livelihood in Assam , India. *Energy for Sustainable Development*, 38, pp.10–20. Available at: http://dx.doi.org/10.1016/j.esd.2017.02.004.

Barua, D.C. et al., 2001. A photovoltaic solar home system dissemination model. *Progress in Photovoltaics: Research and Applications*, 9(4), pp.313–322.

Berg, N.J. van den, 2017. Niche strategy selection in developing countries: a case study on REdesalination.

Bouwman, H. et al., 2001. Chapter 2 Conceptualizing the STOF Model.

Cabraal, A., Cosgrove-Davies, M. & Schaeffer, L., 1996. Best practices for photovoltaic household electrification programs. *Conference Record of the Twenty Fifth IEEE Photovoltaic Specialists Conference 1996*, pp.1357–1362.

Cossio, M.L.T. et al., 2012. Chapter 3 Photovoltaics. , XXXIII(2), pp.81–87. Available at: http://www.ncbi.nlm.nih.gov/pubmed/15003161%5Cnhttp://cid.oxfordjournals.org/lookup/doi/10.1093/cid/cir991%5Cnhttp://www.scielo.cl/pdf/udecada/v15n26/art06.pdf%5Cnhttp://www.scopus.com/inward/record.url?eid=2-s2.0-84861150233&partnerID=tZOtx3y1.

Feldman, D. et al., 2012. Photovoltaic (PV) Pricing Trends: Historical, Recent, and Near-Term Projections. *NREL-DOE Technical Report*, (November), pp.1–30. Available at: http://www.nrel.gov/docs/fy13osti/56776.pdf.

Government of India, 2017. Garv Dashboard. Available at: https://garv.gov.in/garv2/dashboard/garv [Accessed June 15, 2017].

Government of UP, 2011. Welcome to Official Web Site of Uttar Pradesh Government. Available at: http://up.gov.in/upstateglance.aspx [Accessed January 20, 2017].

Hairat, M.K. & Ghosh, S., 2017. 100GW solar power in India by 2022 – A critical review. *Renewable and Sustainable Energy Reviews*, 73(February), pp.1041–1050. Available at: http://linkinghub.elsevier.com/retrieve/pii/S1364032117302149.

Halder, P.K. & Parvez, M.S., 2015. Financial Analyses and Social Impacts of Solar Home Systems in Bangladesh : A Case Study. , 5(2).

Harahap, B., 2014. Barriers & Niche Strategies for Scaling-Up Technology Firms at the Base of the Pyramid.

Harish, S.M. et al., 2013. Adoption of solar home lighting systems in India : What might we learn from Karnataka ? *Energy Policy*, 62, pp.697–706. Available at: http://dx.doi.org/10.1016/j.enpol.2013.07.085.

Holtorf, H. et al., 2015. A model to evaluate the success of Solar Home Systems. *Renewable and Sustainable Energy Reviews*, 50, pp.245–255. Available at: http://dx.doi.org/10.1016/j.rser.2015.05.015.

International Energy Agency, 2015. Energy for Cooking in Developing Countries. *World Energy Outlook 2006*, pp.419–445.

Jolly, S., Raven, R. & Romijn, H., 2012. Upscaling of business model experiments in off-grid PV solar energy in India. *Sustainability Science*, 7(2), pp.199–212.

Karakaya, E. & Sriwannawit, P., 2015. Barriers to the adoption of photovoltaic systems: The state of the art. *Renewable and Sustainable Energy Reviews*, 49, pp.60–66.

Kweka, A. et al., 2011. Feasibility Study on Solar lighting for Poverty Alleviation in Rural Communities in Southern. *Rwanda Journal*, 24, pp.80–92.

Liming, H., 2009. Financing rural renewable energy: A comparison between China and India. *Renewable and Sustainable Energy Reviews*, 13(5), pp.1096–1103.

Luthra, S. et al., 2015. Barriers to renewable/sustainable energy technologies adoption: Indian perspective. *Renewable and Sustainable Energy Reviews*, 41, pp.762–776.

maphill, India: Maps. Available at: http://www.maphill.com/india/ [Accessed June 15, 2017a].

maphill, Uttar Pradesh, India: Maps. Available at: http://www.maphill.com/india/uttar-pradesh/ [Accessed June 15, 2017b].

Martinot, E., Cabraal, A. & Mathur, S., 2001. World Bank/GEF solar home system projects: Experiences and lessons learned 1993-2000. *Renewable & sustainable energy reviews*, 5(1), pp.39–57.

Mathur, K., Oliver, S. & Tripney, J., 2015. Protocol : Access to Electricity for Improving Health , Education and Welfare in Low- and Middle-Income Countries : A Systematic Review. , (February 2013), pp.1–55.

Mathur, P., 2017. Personal Communication. 26 Apr. 2017.

MicroenergyInternationalGmbH, 2014. Solar Home Systems.

Murali, R. et al., 2015. Socio-technical assessment of solar photovoltaic systems implemented for rural electrification in selected villages of Sundarbans region of India. *AIMS Energy*, 3(4), pp.612–634. Available at: http://www.aimspress.com/article/10.3934/energy.2015.4.612.

OECD, 2016. How stringent are environmental policies? Available at: http://www.oecd.org/economy/greeneco/how-stringent-are-environmental-policies.htm.

Ortt, J.R., Langley, D. & Pals, N., 2013. Ten Niche Strategies To Commercialize New High-Tech Products. , (June).

Osterwalder, A. et al., 2010. *You ' re holding a handbook for visionaries , game changers , and challengers striving to defy outmoded business models and design tomorrow ' s enterprises . It ' s a book for the … written by co-created by designed by*, Available at: http://www.amazon.com/Business-Model-Generation-Visionaries-Challengers/dp/0470876417.

Pachouri, A. & Sharma, S., 2016. Barriers to innovation in Indian small and medium scale enterprises. *ADBI Working Paper Series*, (No 588), p.30.

Painuly, J.P., 2001. Barriers to renewable energy penetration: A framework for analysis. *Renewable Energy*, 24(1), pp.73–89.

Pratiwi, L., 2016. Barriers and Strategies for Transition to Electric Vehicles in BRICS Countries.

REC, 2017. REC DEENDAYAL UPADHYAYA GRAM JYOTI YOJANA. Available at: http://garv.gov.in/garv2/dashboard/main [Accessed January 21, 2017].

RuralSpark, Energy Entrepreneur Kit — Rural Spark. Available at: http://www.ruralspark.com/products/energy-kit/ [Accessed June 26, 2017a].

RuralSpark, Overview — Rural Spark. Available at:

http://www.ruralspark.com/products/ruralsparklamp/overview [Accessed June 26, 2017b].

RuralSpark, 2017. Personal Communication. 26 Jun. 2017.

RuralSpark, Rural Spark Value Proposition. Available at: https://static1.squarespace.com/static/5571fa8ae4b0601c9cc7bd6e/t/57dbe1dcb8a79b34cba886f4/1474028069377/RuralSpark_Offer_1.6.pdf [Accessed June 26, 2017c].

Sahni, M., 2017. Personal Communication. 25 Apr. 2017.

SimpaNetworks, Simpa Networks | Solar Revolution In Rural India. Available at: http://simpanetworks.com/ [Accessed May 26, 2017].

Singh, K., 2016. Business innovation and diffusion of off-grid solar technologies in India. *Energy for Sustainable Development*, 30, pp.1–13. Available at: http://dx.doi.org/10.1016/j.esd.2015.10.011.

Solarlove, 2013. How Solar Cells Work -- Components & Operation Of Solar Cells −. Available at: http://solarlove.org/how-solar-cells-work-components-operation-of-solar-cells/ [Accessed June 10, 2017].

The Climate Group, 2013. The Business Case for Off-grid Energy in India. , pp.1–108. Available at: http://www.theclimategroup.org/_assets/files/The-business-case-for-offgrid-energy-in-India.pdf.

Transparency International, 2016. Corruption Perceptions Index 2016 - Transparency International. Available at: https://www.transparency.org/news/feature/corruption_perceptions_index_2016 [Accessed August 5, 2017].

United Nations Department of Economic and Social Affairs, 2014. Electricity and education : The benefits , barriers , and recommendations for achieving the electrification of primary and secondary schools. , (December), pp.1–36. Available at: //sustainabledevelopment.un.org/index.php?page=view&type=400&nr=160.

Urmee, T., Harries, D. & Holtorf, H.-G., 2016. *Photovoltaics for Rural Electrification in Developing Countries*,

Yaqoot, M., Diwan, P. & Kandpal, T.C., 2016. Review of barriers to the dissemination of decentralized renewable energy systems. *Renewable and Sustainable Energy Reviews*, 58, pp.477–490. Available at: http://dx.doi.org/10.1016/j.rser.2015.12.224.

Younger, D.R., 2011. Financing Renewable Energy in Developing Countries : A Global Perspective. , (February).

Zainal, Z., 2007. Case study as a research method.

Zanello, G. et al., 2016. the Creation and Diffusion of Innovation in Developing Countries: a Systematic Literature Review. *Journal of Economic Surveys*, 30(5), pp.884–912.

Zerriffi, H., 2011. Innovative business models for the scale-up of energy access efforts for the poorest. *Current Opinion in Environmental Sustainability*, 3(4), pp.272–278.

Zerriffi, H., 2007. Making Small Work : Business Models for Electrifying the World. , (September), pp.1–45. Available at: http://pesd.fsi.stanford.edu/sites/default/files/WP63,_Zerriffi,_Making_Small_Work_20070926.pdf.