Towards a Spatial Understanding of Solar Energy Transition: The making of a solar energy market in Bangladesh and the experiences of on-grid and off-grid households

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Abstract

This thesis critically analyses the rollout of solar energy technology in Bangladesh and the consequences for the solar energy market and for the everyday lives of on-grid, off-grid households. Electricity is seen as one of the key drivers for economic and social development in countries such as Bangladesh, which has been struggling to ensure sustainable energy access and an uninterrupted electricity supply to all citizens since the independence of the country in 1971. Low carbon energy is rising in importance globally and Bangladesh is heralded as a prime example of the successful implementation of solar energy technology in the Global South, where solar technologies are seen to provide an alternative source of electricity supply and a solution to the longstanding power crisis. By paying attention to the spaces and places of energy transition, this thesis highlights the differentiated outcomes of solar energy provision in urban and rural areas in Bangladesh. Contributing to the growing field of energy geographies, energy for development and other energy social science studies, the thesis draws on ethnographic field research in Bangladesh to expand understandings of solar energy transition. Following a multi-scalar network of actors involved in the implementation of solar energy technology, participant observation, interviewing and visual methods are used to capture the experiences of solar energy integration in both rural (off-grid) and urban (on-grid) lives. In doing so, the thesis makes three arguments. Firstly, that the way solar advocates construct energy problems and advance technical solutions does not recognise spatially constructed and complex relations of power, conflicts of interest, and everyday market politics at a range of scales. Secondly, that energy policy approaches need to recognise the heterogeneity of energy users and the complex ways in which access to, and control over, energy resources varies according to multiple, interlocking and hierarchical systems of differentiation including the intersectionality of class, gender and other social relations. Lastly, that experiences of energy transition are shaped not only by geographical space, but also socio-cultural space in which the geographical situatedness of rural and urban areas shapes the experience of low carbon energy transition.

Key words: Energy Transition; Electricity; Bangladesh; Solar-PV, Rural, Urban, Development, Market, Everyday life, Gender.

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List of Acronyms

ADB Asian Development Bank

ANT Actor Network Theory

BAEC Atomic Energy Commission

BRAC Bangladesh Rural Advancement Committee

BERC Bangladesh Energy Regulatory Commission

BUET Bangladesh University of Engineering and Technology

BPDB Bangladesh Power Development Board

CIDA Canadian International Development Agency

DESA Dhaka Electric Supply Authority

DESCO Dhaka Electric Supply Company Limited

DPDC Dhaka Power Distribution Company Limited

DESCO Dhaka Electric Supply Company Limited

DFID Department for International Development

ESD Energy Services Delivery

EPRSC The Engineering and Physical Sciences Research Council

EU European Union

GIZ The Deutsche Gesellschaft für Internationale Zusammenarbeit

GOB Government of Bangladesh

GEF Global Environment Facility

IDA International Development Agency

HDI Human Development Index

IDCOL Infrastructural development Company Limited

IPP Independent Power Producers

LGED Local Government Engineering Department

LCEDN Low Carbon Energy for Development

KfW Kreditanstalt für Wiederaufbau

kWH kilowatt hour

MDG Millennium Development Goals

MPEMR The Ministry of Power, Energy and Mineral Resources

MNC Multi-National Companies

Mwh megawatt hour

NGO Non-government Organization

NRECA The National Rural Electric Cooperative Association

OECD The Organization for Economic Cooperation and Development

PO Partner Organisations

PPP Public-Private-Partners

PSMP Power Sector Master Plan

RAJUK Rajdhani Unnayan Kartripakkha

REB Rural Electrification in Bangladesh

RERED Rural Electrification and Renewable Energy Development

SDG Sustainable Development Goal

SE4ALL Sustainable Energy for All

SHS Solar Home Systems

SREDA The Sustainable Renewable Development Authority

Tk. Taka (Approx. 70 Taka = US$1)

UN United Nations

UNEP The United Nations Environment Programme

WDI World Development Indicators

WB World Bank

Chapter One: Introduction

Figure 1:1: A small solar home system in Sandwip

1.1 Introduction: the problem of electricity access and the case of Bangladesh

Electricity is considered a catalyst for economic and social development. The absence of electricity is seen as a source of deprivation (Gupta, 2015). Bangladesh has been struggling to overcome an electricity crisis since independence. Over the past 47 years the electricity sector in Bangladesh has come a long way, but per capita electricity consumption (321 kWH) remains one of the lowest in the world. Despite the political priority given to the power sector for decades, the total electricity generation capacity of the Bangladesh Power Sector stands at less than 16 GW (15755 MW) and provides electricity to only 63% of the population (25.4 Million). To overcome the power crisis, a number of initiatives have been undertaken to diversify the sources of energy, and break away from dependence on gas, coal and liquid fuel for power generation. In 2010 the Bangladesh Government decided to increase electricity generation through renewable sources, including solar, wind, and small hydro[1]. Among these renewable energy sources, solar energy has gained substantially higher importance than others. This thesis narrows in on the emergence of photovoltaic solar energy technology in the power and energy sector in Bangladesh and the implications of this new source of electricity for the everyday life of on-grid and off-grid areas, as well as energy markets. In this thesis I argue that we need to understand the spatiality of energy transition, and how the spatiality of energy transition shapes uneven development and practices of power, different forms of energy access and provision, and the market and everyday life.

Energy is also seen as a key factor in achieving sustainable development. It is believed that reliable and affordable sources of energy are fundamental not only for wellbeing, but also for economic growth and poverty reduction (Toth, 2012). Whenever we conceive 'energy' as a means to development, the first dimension that comes to mind is 'electricity'. Because electricity has capacity to make a striking impression by producing bright, radiant light as well as to bring a fundamental impact on the distinction between day and night (Gupta, 2015). Instead of depending on the natural cycles of sun and moon, with electricity daily activities can be shifted in time and space. Further, it is argued that electricity opens up a "second day" for consumption, recreation, and education, illuminates tight urban spaces and the interiors of homes and enables public spaces to be safer and more family-friendly (Nye, 1999; Winther, 2008; Pereira et al., 2011). By opening up extra hours after the sun has set, longer working

[1] Towards Revamping Power and Energy Sector: A Road Map (2010) - a booklet was prepared to outline various immediate, medium term and long-term plan in power and energy sectors. It is also known as Power Sector Master Plan (PSMP).

hours are possible on the factory floor, facilitating the manufacture of goods and the turnover of capital (Woolf, 1984).

Access to modern energy services is now an important global policy goal. In September 2015, when world leaders met to discuss the outcome of the Millennium Development Goals, it was identified that the Millennium Development Goals missed along with others one of the crucial drivers of development, i.e. 'Energy'. Thus, governments worldwide agreed on a set of Sustainable Development Goals (SDGs) and included 'Sustainable Energy for All' under Goal 7. This Goal 7 calls for universal access to affordable, reliable, sustainable and modern energy for all by 2030. A billion people worldwide still lack access to electricity and three billion lack access to clean cooking (Ocwell & Byrne, 2017). Thus, the SDG#7 calls for a global energy transition, with significant improvements in energy productivity, accelerated progress on electricity access using centralised and decentralised sources, and an ever-increasing share of renewable energy to ensure universal access to affordable, reliable, sustainable and modern energy for all by 2030.

However, in that one billion people who live in the dark due to lack of electricity access, a significant part of the population from Bangladesh shares the darkness with other people in different parts of the world. It is believed that a lack of secure and sustainable energy access and supply not only affect the day to day of the life of the people but also affect the overall progress of the country (Wijayatunga & Jayalath, 2008). In 2007 the World Bank indicated a possibility that Bangladesh could join the ranks of middle-income countries (MICs) within a decade (by 2016 or sometime soon after)[2]. However, to achieve this Bangladesh would need to ensure macroeconomic stability, strengthening tax mobilisation and tackling energy sector losses. Also, progress in other areas of economic activity such as the financial sector, external trade, urban management, infrastructure and transportation are all seen to depend on a sufficient and reliable supply of energy (the World Bank Report, 2007). To accomplish this goal, the Bangladesh government has given priority to the power sector, as evidenced by the Bangladesh Power Sector Master Plan 2010.

The government of Bangladesh has realised that to become a lower middle-income country the country needs to attain an 8% GDP growth. To achieve that GDP target, the country's Power Sector Master Plan (PSMP) indicates Bangladesh needs to ensure electricity for all by 2021 which is around 34 GW according to the Power Division of Bangladesh. In 2010 the

[2] On 16 March 2018- The UN declared Bangladesh has fulfilled the eligibility requirements to graduate from 'Least Developed Country' to 'Developing Country' status. Bangladesh will now be able to apply to the UN for recognition as a developing country, while the formal transition will occur on 2024.

current government published a roadmap for the power sector right after taking power from the caretaker government. In the road map, it was estimated that the grid system demand would triple over 15 years from 10 GW in 2015 to 33 GW in 2030. This implies not only a massive increase in demand, but also an equivalent increase in supply. In addition, captive demand – i.e. in areas which the grid is not likely to reach - is estimated to be a further 3 GW by 2030. Under the PSMP 2010, about 15,000 MW of new generation capacity had been planned by 2016 to meet the growing demand for electricity. The plan stipulates the commissioning of a number of quick rental power plants as immediate measures to meet demand in the short run. Favourable Government policies have been introduced to attract private investment and Independent Power Producers (IPP). In 2018 around 45% of total power generation comes from the private sector.

In addition to large scale grid-based additions to power generation, small and decentralised electricity systems have become increasingly popular all over the world, especially in developing countries. For many developing countries, obtaining electricity through access to the grid is not economically feasible, especially for those who live in more remote rural areas power, given the large distances, difficult terrain and low projected levels of consumption involved (Gouvello, 2002). Additionally, due to the greater operational costs involved in distributing electricity in rural areas, the service may be poor or even non-existent in countries where the grid has been extended to serve rural populations (Krishnaswamy, 2010). Thus, decentralised energy is considered one of the best options to meet the rural and small-scale energy needs in a reliable, affordable and environmentally sustainable way for the rural development (Ravindranath and Hall, 1995). Accordingly, the PSMP (2010) places considerable weight on decentralised renewable energy sources and energy efficiency.

It is argued that Bangladesh is endowed with a plentiful supply of renewable sources of energy. Out of various renewable sources solar, wind, biomass and hydro power can be effectively used in Bangladesh. Bangladesh is situated between latitudes 20° and 27° N, which is regarded as privileged position for harnessing solar energy generation. With an average daily solar radiation 4-6.5 KWh/m², and 300 days of sunshine a year (Barua et al., 2014). A maximum amount of radiation is available in the month of March-April and minimum in December-January. An annual amount of radiation varies from 1840 to 1575 kWh/m2 which is 50-100% higher than in Europe (Habib and Chungpaibulpatana, 2014). Thus, solar energy has enormous potential to contribute to the power generation sector, particularly photovoltaic solar energy in the form of mainly solar home systems and mini solar grids.

Furthermore, in 2009 a decision was made in a cabinet meeting to promote solar energy use in the urban areas where the Bangladesh Power Development Board (BPDB)[3] struggles to provide 24-hour secure electricity supply without disruption. Due to the gap between power generation and everyday electricity demand, people who live in on-grid areas suffer from 'load shedding'. To mitigate the energy crisis the Bangladesh Power Development Board decided to promote solar energy use in on-grid areas. Thus, solar energy came to urban areas as part of a solution to a power crisis. This policy requires that all newly constructed buildings must include a rooftop solar power unit with an output no less than 3% of the building's total peak load. Claims have been made that solar energy in the urban landscape is also part of a green initiative by the Government (Power Sector Master Plan, 2010). However, the immediate goal of this policy was to ensure "Load Shedding Free Bangladesh" and solar energy was considered an easy solution.

In 2010 calculations emerged which estimated that if all the high-rise buildings in Dhaka installed solar, it would be possible to produce approximately 300 megawatts of electricity from some 20,000 multi-storied buildings in the city ('Rooftop solar systems can ensure uninterrupted power' reported in The Daily Star, 5-06-2010). Seeing the huge potential, the Ministry of Power, Energy and Mineral Resources decided to push forward a solar policy in June 2011 and prepare a new building code with mandatory provision for rooftop solar panels. The draft laid out mandatory provisions for the installation of solar panels that could generate at least 2 percent of the total power demand of residential buildings, and 5 percent of the demand of commercial buildings under the jurisdiction of Rajdhani Unnayan Kartripakkha (RAJUK)[4]. In order to popularise this initiative, a number of public or government offices installed solar PV, such as the Prime Minister's office ('PMO goes under solar energy soon' reported in The Daily Star, 14-02-2010) and the Bangladesh Bank (State bank of Bangladesh) ('Solar power lights up BB reported' in The Daily Star, 31-03- 2010). These were considered symbolic of the government-led 'green move'.

This thesis aims to understand the implications of this global and local agenda on the energy sector in Bangladesh, and how photovoltaic solar technology came to be established as an important tool for the development of Bangladesh. Bangladesh's recent experience of economic development is frequently celebrated as a parable of what an early and sustained

[3] The Bangladesh Power Development Board (BPDB) is a public sector organization that is responsible for planning and developing the nation's power infrastructure and for operating much of its power generation facilities.

[4] Rajdhani Unnayan Kartripakkha (RAJUK) is a public agency responsible for coordinating urban development in Dhaka.

commitment to economic liberalism can achieve (Hossain, 2017). In a recently published book 'The Aid Lab', Naomi Hossain, a political sociologist and former development specialist, states "a poor, populous country chooses the path of global capitalist development, resisting many of the temptations of dirigisme opted for by so many power-happy post-colonial elites… Bangladesh—that notorious basket case, with its hungry millions, that byword of bywords—has dragged so much of its population out of poverty is surely proof the development experiment works. If Bangladesh can do it, anywhere can" (p. 1). The success of Bangladesh is now celebrated in international development as a surprise, an example of inspiration for other developing countries who are still struggling to establish a happy image of Bangladesh[5].

What are the images of Bangladesh in the international development domain? The majority are generally adverse, such as floods, climate change and Rana Plaza, with the exception of NGO microcredit programmes which are considered successful, and women empowerment through women's participation in the liberal market through the garment industry. Lately, another positive image of Bangladesh is that it is an exemplary case in the renewable energy market. The solar energy market of Bangladesh is considered the fastest growing renewable energy market in the world (The World Bank, 2014). In a report by the Climate and Development Knowledge Network (2011) it was stated that "Bangladesh has the fastest expansion of solar use anywhere in the world. In 2002, just 7,000 households in Bangladesh were using solar panels, but now more than one million households, or five million people, are benefitting from solar energy". Over the following years this number tripled. By May 2017 about 4.12 million solar home systems (SHSs) had been installed under the Infrastructural development Company Limited- a state own non-financial Bank (IDCOL) solar home system problem, and solar mini grids and non-donor-based markets had been established all over Bangladesh. Out of the 18 Solar Mini-Grid Projects given approval, seven were operational while the rest were under construction under the IDCOL's Renewable energy program. The programme operates in the remote areas where electrification through gird expansion is challenging and costly.

According to IDCOL's website 'the program has ensured a supply of solar electricity to 18 million people, i.e. 12% of the country's total population who previously used kerosene lamps for lighting purpose'. The website also states that the programme aims to finance 6 million SHS and 50 mini grid grids by 2021, with an estimated generation capacity of 220 MW of electricity'. IDCOL also claims that the program has so far reduced the consumption of

[5] In July 2015 Bangladesh advanced from a lower income country to a lower-middle income country based on the per capita income categories provided by the World Bank.

kerosene by 14 million tons of kerosene worth USD 411 million. In addition, over the next 15 years, the newly-installed 4.1 million solar home systems will lower consumption by another 3.6 million tons of kerosene worth USD 1,300 million. Thus, this thesis tries to understand how Bangladesh came to acquire a leading position in the global renewable energy sector, and what kinds of consequences this fastest growing market has for people on the ground.

1.2 Conceptual Overview

This thesis examines the transition to solar energy in Bangladesh, within the context of a broader development process, with attention to market creation and its impact on the everyday life of urban (on-grid) and rural (off-grid) areas of Bangladesh. This research has taken 'energy transition' as the central concept in order to understand changing relations between energy and everyday life on the on-grid and off-grid areas of Bangladesh with the emergence and development of solar energy technology in recent years. Energy transitions research offers a set of tools and concepts able to describe and explain the process of transformation from one energy system to another (Baker et al. 2014). This study not only describes the process of energy transformation, but also explains an ongoing 'geographically-constituted' process of solar energy transition in Bangladesh. Bridge et al. (2013) argue that the concept of transition does not imply any consensus about a desired end state: rather it is a geographical process that involves changes in spatial relations, including those 'everyday' relations of living and working with energy.

The conceptual framework that this study uses builds on Bridge et al. (2013) who suggest that "low carbon transition as a simultaneous process of geographical equalization and differentiation has the potential to produce new patterns of uneven development" (p. 317). According to Bridge et al. (2013), understanding transition as a geographically constituted process has three implications for energy policy. Firstly, spatial difference and the fundamentally uneven nature of spatial interactions are both potentially disruptive to the policy because they complicate many its assumptions: understanding the way these interactions and interrelations can enable or frustrate policy goals is therefore of practical value. Secondly, space is a necessary condition for the possibility of multiple, co-existing energy pathways and, therefore, an important source of variety and experimentation: there are significant opportunities, therefore, for understanding the relationship between different trajectories of energy transition and the geographical conditions from which they emerge. Thirdly, it highlights how implementing a low- carbon economy will be a simultaneously creative and destructive process that significantly changes how different places are related to each other, economically, politically and even culturally, and at a range of different scales (p. 339).

Although energy has been an important topic in the scholarship of geography since the 80s, low carbon energy, especially in the global south, is a relatively new area of work for many geographers (Ockwell & Mallett, 2012; Ockwell & Byrne, 2017). Scholars who use the 'transition' as a guiding framework for research mostly use the socio-technical transitions as "orderly and managed process of change". It has been argued that the socio-technical transitions of energy transition do not happen on the ground every time in all contexts (Baker et al. 2014). In addition, socio-technical transitions of energy transition theory falls short in providing adequate 'tools' to analyse everyday life, politics and power dynamics between heterogeneous actors as it places too much emphasis on "elite actors" and it fails to capture everyday life or ordinary actors (see Byrne, 2009). It also lacks a grounding of transitions in geographical contexts on uneven development. Thus, to understand solar energy transitions in Bangladesh, the research focuses on the spatial understanding of energy transition in everyday life of both on-grid and off-grid locations.

Through spatial analysis of energy transition, the thesis extends existing debates in energy transition with expositions from the political economy of low carbon energy transition. Political economy provides a lens through which to engage with a set of theoretical perspectives that connects us to a better understanding of donor-driven development programmes which lead the national political context (Brown & Cloke, 2017). Political economy inspires researchers to raise questions about 'who wins, who loses, how and why' as they relate to the existing distribution of energy (Newell et al. 2011). It also asks who lives with the side effects of its sites of extraction, production and generation, and who will bear the social costs of decarbonising energy sources and economies (Newell & Mulvaney, 2013). As an analysis from a political economy perspective emphasizes the importance of history, the role of politics, social relations of production, international economic structures, and the relationship between capitalist development and economic changes, it shapes this research by challenging the relation between energy transition and development. In this context, the global agenda 'SDG#7' and local agenda 'Electricity for all by 2021' merge together and draw attention to a specific case of solar energy transition in the field of energy scholarship. Thus, the political economy of solar energy transition in Bangladesh helps this thesis to understand how the government, NGO and private organisations are dialectically related, and how development processes influence that relationship.

While the literature on energy transitions provides useful insights into the drivers of change and the actors that have to be on board for technologies and mode of production, the political economy of transitions brings the exercise of power by state and corporate elites that shapes a process of energy transition. Where both energy transition and the political economy of

energy transition often fall short is the impact of energy transition on people's life (Campbell, et al. 2016) and their everyday life. Everyday life is the observable manifestation of social existence that makes social life visible (Sztompka, 2008). Rigg (2007) argues studying the everyday means going beyond structures to understand the personal that makes ordinary people and their lives extraordinary. In energy research, analysis of everyday life and energy sees energy as an invisible material (Lutzenhiser et al. 2009), and that it can only be visible when we focus on the 'visible use of energy', 'materials practices', 'process', 'technologies' and 'persons' that consume energy (Pink, 2011). An everyday life lens helps us to understand the impact of any development programme, as there is a tendency for development literature to emphasise the measurable and quantifiable outcome of a development programme. Winther (2015) points out that quantifiable estimations of social benefit shape the success of development projects in the realm of electricity and development. In the case of the low carbon energy transition in developing countries, the quantifiable development successes are the number of instalments, educational achievements or school enrolments, reduced usage of kerosene, increased number of jobs, carbon emission statistics etc. These failed to capture the sociocultural and material context and process of electrification (Winther, 2015). Castán-Broto et al. (2017) suggests that energy research should have a people-centred perspective on energy access.

Finally, this thesis has given special attention to a detailed and contextually attuned analysis of the living conditions of people without access to electricity, as this is crucial for understanding the implications of small size solar energy in rural life; and a stronger focus on what it means not to be connected with national grid brings valuable insights. Inspired by the postdevelopment literature, this thesis emphasises local voices and acknowledges the heterogeneity of local needs and local perspectives (Esteva, 1987; Sachs, 1992; Escobar, 1995) towards low carbon energy transition.

1.3 **Research Questions**

The central focus of this research is understanding the roll out of solar energy in Bangladesh and the social consequences of the country's solar energy transition. With this broad objective, this research asks following questions:

- How does solar-PV emerge - and subsequently roll out - as an alternative source of electricity supply in the power and energy sector in Bangladesh?
- How do people in on-grid and off-grid areas integrate solar energy into their everyday life?

- To what extent do solar energy interventions work to achieve particular goals of development?

This thesis aims to contribute to energy geographies scholarship and energy for development literature by providing an account of the spatial process of energy transition, using the examples of solar energy transition in Bangladesh. Low carbon energy transition has recently been adopted by many developed and developing countries to tackle the issue of climate and development. From the secondary literature, it is identified that out of all the low carbon energy options, solar energy has gained significant attention. This thesis will add to knowledge about the spatial context of solar energy transition of the global south, using the example of low carbon energy transition in Bangladesh. In addition, each research question, explored in chapters 5, 6, 7 and 8 connects and adds new theoretical insights to the literature on energy transition, political economy and everyday life. Thus, the thesis is not only important for the energy transition research, but also contributes to the scholarship of development urban geography. At the policy level, the thesis also identifies the current gap between contemporary projects and literature and what sort of unintended consequences this kind of project brings to people lives.

1.4 **Thesis Structure**

This thesis is organised into nine chapters. Following this Introduction, Chapter Two (Literature Review) presents the key literature and debates that shapes this thesis. In this thesis I use a spatial perspective on energy transition as a key framework. Here I bring two bodies of literature together: research on energy transition, and work on energy for development. The chapter also identifies that the human oriented, everyday life of energy users is mainly missing in those literatures and, in response, suggests an approach to studying low carbon energy transition in the developing countries that gives the concept of ‘everyday life’ a central role. This concept plays a vital role in shaping the thesis, as everyday life helps unpack the social existence of solar energy technology and the relationship between solar energy technology with its users. In addition, the literature on postdevelopment has been an inspiration in shaping this research. The key argument of postdevelopment theorists encouraged me to think critically about the whole practice of energy for development through the deployment of solar energy technology that the majority of the energy for development literature has failed to address.

Chapter Three (Methodological Reflections) outlines the methodology and methods used in the research. It reflects on these methods by thinking about the process of doing research as a journey, and highlighting the fieldwork experience it entailed. Here I posit that an

ethnographic approach is useful for energy research as it involves mundane life with given technology. I also reflect on issues raised by critical scholars, especially feminist geographers, on the research process, such as positionality, reflexivity, power relations, and the production of knowledge in this chapter.

Chapter Four to Chapter Eight are the heart of this thesis. Chapter Four (Power and Energy Sector Reforms: Emergence of Solar Energy in Bangladesh) provides contextual information on the reform process in the power and energy sector in Bangladesh, and the way in which solar-PV technology emerged as an alternative source of electricity supply. Engaging with political economy literature the chapter brings the historical perspective of different policies as a part of the power and energy sector reforms. At the end of the chapter, I situate the context of the photovoltaic solar energy programme and how it evolved into its current shape. Thus, this chapter provides crucial context for understanding the rest of the empirical chapters (Chapter Five to Chapter Eight) as it outlines the current situation of solar energy technology in Bangladesh. Having contextualized the existing settings of electricity sector and the emergence of various solar energy programmes, I go into greater details of the process of making a market for solar energy technology and the consequences of this market making on everyday practices in the energy sector in Chapter Five (Making a Market for Solar Energy Technology). In this chapter I argue the discourse of electricity crisis and shortage plays a vital role in fulfilling the neoliberal motif of development and accelerates the process of market making for solar energy by opening a door for private entities. The chapter concludes that while too much attention is given to building a market for solar energy technology, insignificant attention is paid to how to make it sustainable. Overall, then, Chapter Four and Chapter Five help to answer the first research question (RQ. 1) - how does solar-PV emerge, and subsequently roll out, as an alternative source of electricity supply in the power and energy sector in Bangladesh?

Having examined the context and market formation of solar energy technology in Chapter Four and Five, following three chapters (Chapters Six, Seven and Eight) shed light on the experiences of solar energy users in on-grid and off-grid households in Bangladesh. Chapter Six and Chapter Seven are closely connected, as both chapters explore the experiences of solar energy users in rural areas or, more precisely, off grid areas in Bangladesh. Using the concept of ‘everyday life’, Chapter Six (Living in an Off-Grid Life) presents the mundane life of people who live in Sandwip Island, an off-grid island located in the South East coastal areas of Bangladesh. In this chapter, I show in detail how people manage and meet their day to day energy needs and how solar energy intervenes in their day to life. This chapter, therefore,

answers a part of the second research question (RQ. 2) - how do people in off-grid areas integrate solar energy into their everyday life?

Presenting everyday life of solar energy users in Sandwip in Chapter Six, the thesis carries on with the experiences of off grid households but highlights the relation between rural development and solar energy transition. Inspired by postdevelopment literature in Chapter Seven (Solar Energy for the Rural Development) I critically analyse and challenges the development narratives that contributed to the rise of solar energy in the field of international development - these are socio-economic development, women's empowerment and rural development. In this chapter I argue that solar energy technology in rural Bangladesh makes an insignificant contribution to poverty reduction. Gender based analysis in this chapter demonstrates that solar energy technology reinforces and intensifies social and gender inequalities at various levels in society. In this way, Chapter 7 answers the third research question (RQ. 3) - to what extent do solar energy interventions work to achieve particular goals of development?

Having examined the experiences of energy users in off grid areas, this thesis moves to explore the user experience of people who live in on-grid areas. In the final empirical chapter, Solar Energy on Urban Rooftops (Chapter Eight), I examine the impact of solar energy transition in on-grid areas and the everyday experiences of solar energy users in city (Dhaka) who are also connected to the national grid. I explain how solar energy technology in on-grid areas appeared as an additional source of electricity generation to reduce pressure on the national grid. Thus, in this chapter, I investigate how people perceive the solar energy policy in on-grid areas and how people integrate this new source of electricity in their everyday life. By highlighting the experiences of urban dwellers with solar energy on their rooftops, this chapter helps us to understand the importance of spatial differences to the process of solar energy transition and the experiences of urban dwellers with solar energy on their rooftop.

Finally, Chapter Nine (Conclusion) concludes the thesis by summarising the key themes drawn out and lessons learned. Here I conclude with reflections on the impact of the global agenda 'Energy for All 2030' and local agenda 'Electricity for all by 2021' on the everyday life of different actors. The notion of shortage and concern about climate change play an important role in the creation of a market for the solar energy. However, the geographical location, availability of other sources of electricity, material capacity of solar energy technology, social relations and power relations among institutions all interact at a variety of scales and spaces to produce the present crisis, where solar energy and development discourses are both contested and reproduced. Through the integration of the conceptual frameworks that draw from various imbricated strands of scholarship within and outside of geography, the thesis

attempts to show that social context, historical trajectory, and political and developmental processes interplay, and shape and are shaped by the present situation, and will continue to do so in the future.

1.5 Contribution of the thesis

In addressing the above questions, within the rationale and context presented in this chapter, this thesis makes a contribution to our knowledge in the scholarship of energy transition by giving attention to space, place and geographical situatedness of a low carbon energy transition in the Global South. By paying attention to the spaces and places of energy transition, this thesis highlights the differentiated outcomes of solar energy provision in urban and rural areas in Bangladesh. The thesis draws on ethnographic field research in Bangladesh to expand understandings of solar energy transition and contributes to the growing field of energy geographies, energy for development and other energy social science studies.

The main contribution of this study is field-based insights into spatial differences (urban vs. rural) in the experience of solar energy transition and the complex relations of multi-scalar actors who are actively involved in this process of transition. The literature that narrates the experiences of low carbon energy transition in the Global South mostly explored the experiences of rural or off-grid areas (See Turner, 2015, Kumar, 2015, Gent, 2014). By contrast, very little attention has given to the experiences of low carbon energy transition in urban or on-grid areas in the Global South (see Castán-Broto et al. 2017, Luque-Ayala, 2012). Thus, this study is distinctive and makes an original contribution by including experiences of solar energy intervention in both rural (off-grid) and on urban (on-grid) areas and showing how different energy landscapes have shaped the solar energy transition in Bangladesh.

Besides, this study contributes to gender studies. The thesis has identified that gender is an understudied area in the energy transition literature. The studies that engaged with gender analysis in energy policy and energy access studies, especially in the Global South, have focused primarily on cooking energy (Cecelski 1992, Skutsch 1995, Dutta 2003, Miller and Mobarak 2013) and only few examine the impact of electricity on women empowerment (see Winther 2011, 2015; Winther et al. 2017). The emphasis on gender analysis in this doctoral research has allowed it to understand the similarities and differences in the experiences, perceptions, and realities of both male and female users of solar technology. Findings of this study show that different forms of solar technologies reproduce a stereotypical division of labour between men and women, and also reinforce gender disparities in access to resources and services. Through this research, I contribute to gender studies using the specific case of solar energy provision in the Global South.

Finally, this research provides a rich ethnographic insight of the lived experiences of solar energy users in on-grid (Dhaka) and off grid (Sandwip) areas in Bangladesh. In exploring the everyday life of solar energy users, this thesis reveals the aspirations, experiences, and needs of people who live in on-grid and off-grid areas in Bangladesh and how they manage their everyday energy needs. Placing the end user at the centre of analysis, this study contributes to a new empirical insight to debates over end-users' experiences with small scale solar energy technology in developing countries.

Chapter Two: Literature Review

Figure 2:1 A solar panel is recharging its battery from the Sun

2.1 Introduction

"*Energy powers human progress. From job generation to economic competitiveness, from strengthening security to empowering women, energy is the great integrator: it cuts across all sectors and lies at the heart of all countries' core interests. Now more than ever, the world needs to ensure that the benefits of modern energy are available to all and that energy is provided as cleanly and efficiently as possible. This is a matter of equity, first and foremost, but it is also an issue of urgent practical importance—and this is the impetus for the UN Secretary-General's new Sustainable Energy for All (SE4ALL) Initiative*".

(Forwarded by Bazilian cited in Sovacool and Drupady, 2012)

This chapter presents key debates and literatures that shape this research. This thesis aims to understand geographically constituted processes of solar energy transition in Bangladesh and the impact of this transition on everyday life in off-grid and on-grid areas of Bangladesh. This research takes 'energy transition' as the central concept and focuses on the emergence and development of solar energy technology in Bangladesh. Here I would like to admit that using 'energy transition' as the central concept for this thesis was not straightforward. Rather taking a pre-confined theory, this study has gone through an exploratory route to identify its central theoretical framework. As we know that research on energy system are inherently social and technical because of the nature of the topic, the dialectic relations among science, technology and society have received the attention of social researchers on energy issues for a while (Wong, 2016). Influenced by the broad interdisciplinary research team Photovoltaics for Future Society (see Chapter Three), this research initially consulted Actor Network Theory (ANT) as a mode of thinking to understand the expansion of solar energy in Bangladesh.

Actor Network Theory (ANT) is a theoretical and methodological approach that believes the social and natural worlds exists in constantly shifting networks of relationship. The fundamental aim of ANT is to explore how networks are built or assembled and maintained to achieve a specific objective (Latour, 1987). As a theory ANT is open to objects, ideas, processes and any other relevant factors, which it considers as important as creating social situations as humans. For this reason, I initially engaged with the literature on ANT to explore the network of solar energy in Bangladesh. Increasingly what I realised, however, was that ANT does not account for pre-existing structures, such as power, but rather sees these structures as emerging from the actions of actors within the network and their ability to align in pursuit of their interests. Scholars like Bloor (1999) and Restivo (2010) argue ANT's

vocabulary and analytical tools cannot challenge power structures but can only describe them. Similarly, Harding (1991, 2008) argues ANT is incapable of challenging the power structures and so falls short by not including important social factors such as race, class, gender, and postcolonialism.

Through constant examination of various theoretical debates and energy literature, this study came to recognise ongoing debates where scholars sought to develop an understanding of energy transitions as uneven social and spatial processes (Calvert, 2016; Huber, 2015; Rutherford and Coutard, 2014). For example, Bridge et al. (2013) argue energy transitions encompass the 'reconfiguration of current patterns and scales of economic and social activity' (in which 'people and places unevenly experience the costs and benefits of energy extraction, generation, financing, distribution and consumption' (Newell and Mulvaney, 2013: p. 4) that not only helps this research to identify the pre-existing power structure of a network but also the uneven experiences of people and places in any given context.

In light of this brief account of the thesis' conceptual evolution, this chapter has three objectives: firstly, it reviews key energy literature in energy geography and other closely relevant disciplines; secondly it highlights an important gap within current contemporary energy research as these literature fall short to pay attention everyday micro politics and geographical situatedness of energy transition; and thirdly it proposes an approach to studying low carbon energy transition in the global South. In order to achieved this, I divide the key energy literature into two broad categories: Energy for Development and Understanding Energy transition in the Global South. Using these broad categories I explore not only the key literature and debates around each theme but also highlight other literature that has been inspirational for this research and shaped its ultimate analytical framework. The following section presents key literature debates around energy for development.

2.2 Energy for Development

Energy is recognised as a key issue in achieving sustainable development for all. It is believed that reliable and affordable sources of energy are fundamental for wellbeing, economic growth and poverty reduction (Toth, 2012). "Electricity provides a range of desirable services such as the electric light and the use of mobile phones and is regarded as a conditional factor for economic growth" (Standal and Winther, 2016: p. 27). Providing energy services such as electricity to every citizen is expensive and time consuming, thus decentralised energy services is considered the most effective and viable for the developing countries (Bhattacharyya & Palit, 2016). Neo-populist vision ''small is beautiful'' and self-reliance has made decentralised energy provision popular (Jacobson, 2007). Myriad publication can be

found on the benefit of decentralised electrification in the global south, mostly focussing on benefits from renewable energy village electrification system (Zahnd & Kimber, 2009), assessment of photovoltaics solar energy based decentralised rural electrification (Chaurey and Kandpal, 2010), solar energy system electrification as a viable technology for Africa's development (Wamukonya, 2007), socio-economic impact of solar home system in Sri-Lanka (Wijayatunga and Attalage, 2005) and so on.

Many have written about the benefit of solar energy in off-grid areas in developing countries. Barua (2001) claimed solar energy programmes in Bangladesh can benefit the living, help preserve fossil fuels and help alleviate poverty by providing income generation opportunities while women's welfare, children's education and so on may also be improved. Solar energy is considered as life altering devices for poverty reduction. According to Mondal and Klein (2011), solar electrification provided direct and indirect benefits to the users of the system. It helps to reduce pollution, higher quality light and more hours of light in the evening, as well as less work for cleaning kerosene lamps for women. Similarly, Komatsu et al. (2011) argue solar energy users gets two kinds of benefits, first, the installation of SHS can reduce the costs of fuel such as kerosene and secondly it improves the lifestyle by offering the household - electric lighting, watching television, and the ease of mobile phone recharging at home. Others believe, the contribution of SHS in rural households is also extensive in terms of convenience, improvement in the quality of life, safety, and better quality of lighting from electric as opposed to kerosene lamps (e.g. Martinot et al., 2001; Urmee et al., 2009).

Some literatures present the experiences of different projects of solar energy in the developing countries from various perspectives. For examples, Martinot et al. (2001) explore learning from twelve projects that provide energy services to off-grid rural households in developing countries by enhancing markets for solar home systems. In the paper, the authors point out solar home system projects in different developing countries face a myriad of difficulties operating in rural areas, these are: lack of an established market, lack of successful business models, lack of business financing and skills, unwillingness of utilities to provide off-grid electricity services, high transactions costs, high first cost and affordability, credit risk is a serious concern of both financiers and dealers and makes credit sales particularly challenging and also a lack of consumer financing (p. 42). Obstacles and hindrances of diffusion of solar energy in the global south have been leading energy literature for quite some times. For example, Wong (2012) identifies three key obstacles that constrain poor people from obtaining solar lighting: financial exclusion, weak governance, and passive NGO and customer participation. Like, Wong, Sovacool et al. (2011) also identifies four types of barriers in order to accelerate distribution of solar energy system in developing countries. These are: technical

barriers, economic barriers, political barriers and social barriers. Drawing on empirical work in Papua New Guinea, this paper recommends solving these barriers by giving emphasis on substandard equipment and logistical problems, poverty, lack of financing, institutional capacity and government commitment to fossil fuelled grid electrification.

While most of the literatures are concerned about diffusion of solar energy and possibility of increasing solar energy installation, only a few emphasise the importance of monitoring and maintenance (Palit, 2013). Some literature shifts their focus from a success story to a failure story of some solar energy programme. According to Wijayatunga and Attalage (2005) and Laufer and Schäfer (2011) Sri Lankan solar energy programme failed because of its “two hands model”. In Sri Lanka the households were not satisfied with the service quality offered by the solar firms and the majority felt that the service personnel needed to visit the households more frequently. Because of its “two hands model” solar consumers in Sri Lanka avail the finance from the PCIs and procure the systems from solar firms, thereby having to deal with two different agencies. As the solar firms were not responsible for getting the repayment of the loans availed, they seem to be providing less importance to the after-sales services as payment default is directly not impacting them. PCIs bear the brunt of the poor service as delay or failure in providing the service directly impacts the loan repayment (Laufer and Schäfer, 2011).

Along with illumination of darkness, solar energy technology can also be a potential for extending market from the North to the South. Miller (2010) describes the market potential relating to the diffusion of renewable energy devices. This literature looks upon the economic potential of solar energy market in the developing countries. This follows a socio-political imagination in which poor in the South is seen as an active and capable consumer, poor are seen as new profit-making opportunity for corporation (Prahalad, 2010). Prahalad (2004) brings the idea of “bottom of the pyramid” into attention and introduces a market-based scheme in development landscape through microfinance. This approach marries development practice and the pursuit of profit, maintaining the development goal can be achieved by simply extending the scope to those who are not active in capital market. BOP scheme aims to repurpose “under-utilized” members of society in developing countries. For the past two decades, development practice in a neoliberal context shifted from state to market led development approach (Elyachar, 2005; Rankin, 2001).

From the above-mentioned literature, it can be said that most of the time these researchers seek questions regarding what can be done to make the technology better, or programmed better, what are the barriers to the diffusion of solar energy in developing countries. How could we succeed more if we can improve technologies? These barriers can be financial, technical,

cultural or social, in either way the goal here is to understand these barriers with the aim of removing them to enable more people to get access to electricity. These are not all in favour of the market-based ideology, but they do all have a very clear goal of enabling as many energy technologies as possible to reach as many people as possible. These literatures have already taken for granted that solar energy is the only option for development. These literatures do not ask any question why, how, who in their research or publications. These are crucial to consider in order to understand politics of any energy transition. We need to ask, 'who is (or is not) represented and included in decisions; where and at what scale decisions are made; whose knowledge counts and why; how power relations influence' (Lawhon and Murphy, 2012)

Not many energy researchers have asked who is represented or who is not represented, whose opinions matters, where and at what scale decisions are made; whose knowledge counts and why; how power relations influence and decision are made in the field of development. Who is represented, whose knowledge counts and why; how power relations influence- these questions have been asked by the postdevelopment scholars in order to understand the impact of donor driven development programmes in developing countries (See Escobar, 1994; Esteva, 1992; Rahnema, 1992; Sachs, 1992; Ferguson, 1994). Postdevelopment theory is one of the most compelling and provocative fields of thought in contemporary development studies. The postdevelopment scholars argue the development industry is often ignorant of the local, cultural and historical contexts of the peoples to which they are applied. It comes to this conclusion by showing how the whole idea of development is premised on a set of knowledges and interventions which are Eurocentric but which claim to be of universal significance.

My approach in this thesis has been to use postdevelopment literature as a stimulus for research, rather a grand theory. Postdevelopment theory is by no means a unified school of thought. Simon (2003), for example, distinguished between "antidevelopment" and "postdevelopment" (p 36). For him Anti-development texts present a radical and derisive critique of development, criticising it for causing cultural destruction and dependency (see Escobar 1995). In contrast, Simon believes postdevelopment theory is positive, optimistic and forward-looking where scholars propose new alternatives to development (see Esteva and Prakash, 1998). Similarly, Aram Ziai (2004) categorise the postdevelopment scholars into two categories: reactionary populist and radical democratic. For Ziai (2004) the reactionary populist rejects modernity completely and advocates a return to a romanticized, subsistence-based existence such as Alvares, (1992), Rahnema and Bawtree (1997). On the other hand, the radical democratic favours radical decentralization

and the rejection of universal models (see Escobar, 1995; Esteva and Prakash, 1998; Banuri, 1990, 1990). Here I want to clarify that the aim of this study is not to judge whether the idea development is good or bad, or to try to make an attempt to decide which postdevelopment school of thought is correct. Instead, for this study postdevelopment literature is an inspiration that helps identify and ask critical questions about power structures, social inequality, and gender discrimination that have often been ignored by energy for development scholars.

Inspired by this critical lens, a growing body of literature has adopted a critical lens in order to understand the impact of solar home systems in developing countries from a post-development perspective. Drawing on Kenya's solar electrification programme, Jacobson (2007) argues that although it has been claimed different initiatives have been taken to ensure electricity access for all, solar electrification programmes in Kenya are captured by the rural middle class primarily. On the other hand, solar PV plays a modest role in supporting economically productive and education-related activities, but ''connective'' applications such as television, radio, and cellular telephone charging often receive a higher priority. He also finds the solar electrification programme in Kenya is more closely tied to increased rural TV use, expansion of consumer goods markets, more rural–urban communication, and other processes that increase rural–urban connectivity than to poverty alleviation, sustainable development, or the appropriate technology movement (p. 157).

In addition, Bhattacharyya (2006) claimed Solar Home System SHS has limited impact on poverty alleviation as it is not able to meet the most important energy demand, i.e. cooking. Bhattacharyya argues in one hand the environmental benefits are also limited, the income level of the poor is not high enough to install SHS in another, and therefore it has only limited impact on the rural population. Unlike Bhattacharyya (2006), Rahman and Ahmed (2013) doubt whether Solar Home System (SHS) in rural Bangladesh is Ornamentation or fact of development? This study found that overall rural development in Bangladesh has not been influenced significantly so far even with widespread dissemination of SHSs. Indicators of Human Development Index (HDI) and Word Development Indicators WDI, although not significant in number and scope, do not show any particular link of SHS to rural development. Rahman and Ahmed (2013) challenge a popular claim that solar home systems help income generative work. According to them, employment and income generation level has been very minimal, increased access to energy through SHS in rural Bangladesh provides mostly recreational and leisure benefits with the so called 'social status'.

Sovacool (2014) identifies a pattern of energy debates in developing countries. Energy debates are often led by male engineers and economists from North American and Europe,

their concern is about technology and business model/ barriers to diffusion, these debates often miss human centered questions such as 'which technologies and programs have helped combat poverty and which have not' and an important question such as 'who are the winners and losers in these initiatives'? This raises important questions that take us to the question that political economy of energy transition literatures ask the energy researcher to ask. Cloke et al. (2017) is critical about the energy projects in the Global South as those projects always have been framed within a top-down technologically-driven framework that limits their ability to provide sustainable solutions to energy poverty and improving livelihoods. This framing is linked to how energy interventions are being imagined and constructed by key actors in the sector, via particular sociotechnical imaginaries through which a set of increasingly universalised energy futures for rural communities is prescribed. On the other hand, human centered questions can fulfill the gap when the socio-technical perspective overshadow important elements of energy transition i.e. people, the energy users.

Here I want emphasis energy policies rarely address gender issues explicitly (Winther et al., 2017). According to Clancy et al. (2011) national policies for electrification are often gender-blind or they primarily focus on women's domestic roles (Kelkar & Nathan, 2005). In the earlier section I demonstrated that the major focus of policies and programmes is to provide electricity access, making services affordable and enhancing availability and reliability. A large part of the gender discourses in energy policy and energy access studies, especially in the Global South focused mostly on cooking energy (Cecelski, 1992; Skutsch, 1995; Dutta, 2003; Miller and Mobarak, 2013). Not many policy studies have been conducted to evaluate electricity and the challenges encountered by women in terms of access, participation in decision-making, policy reforms, etc. (Panjwani, 2005; Cecelski ,2005; Kohlin *et al.,* 2011; Oparaocha and Dutta, 2011).

Winther (2015) points out a crucial gap in measuring the success of energy projects. Winther (ibid) argues the evaluation process as a whole do not pay attention to the social or political process of electrification, therefore those evaluations barely add any new knowledge. Generally, success of a solar energy programme is measured by number percentage of school attendees, how much kerosene use is reduced per year, how many jobs are created for both skilled and unskilled labourers (see Sharif and Mithila, 2013; Wijayatunga and Attalage, 2005). According to her project evaluation focuses on observable and measurable, implied focusing on number of connections and examining people's consumables and segment of their finances. Focusing on observable and measurable or structural evaluation of a programme, loses sight of the moral economy and social conditioned patterns of consumption. Thus,

qualitative examination of the sociocultural and material context is important in order to understand impact of new technological transition. Therefore, this research believes we need to pay more attention to qualitative research on energy and by following everyday life.

Low carbon energy transition in on-grid or urban areas in the global south is not as vast as studies of rural off-grid areas. Much has written about the multiplicity and richness of climate change action in urban areas (Bulkeley and Betsill, 2005; Bulkeley and Castán Broto, 2013; Castán-Broto and Bulkeley, 2013), but little has been paid attention to these actions linked to an urban energy transition (Bulkeley et al., 2014; Rutherford and Coutard, 2014; Seto et al. 2014). Usage of urban rooftops for green and eco-friendly activities has been gaining popularity lately. Yuen and Hien (2005) argue that interest in the role of open space in the urban environment has increased in recent decades due to the international focus on sustainable development. Different policies for creating and preserving open space are increasingly implemented at a variety of urban densities and spatial scales in various countries; for example, a rooftop garden in Singapore (Yuen and Hien, 2005), rain water harvesting and a water reservoir in Mumbai (Button, 2016), rooftop solar electric potential in Seoul (Byrne et al. 2015), and a rooftop revolution through solar technology (Kennedy, 2012). In addition, The Asian Development Bank (2014) published a handbook on rooftop solar development in Asia, exploring the prospect of using urban rooftops and recommending future interventions in these open spaces which are often underutilised[6]. Luque-Ayala (2014) sees energy transition as a material and socio-political transformation that is mobilised and transformed. Luque-Ayala (ibid) argues the governmental rationales involved in the making of a local governance of energy, the key governmental techniques involved in operationalizing a solar energy regime, and the multiple ways in which energy subjects are imagined within this process.

2.3 Understanding Energy Transition in the Global South

The notion of an ‘energy transition’ has no universal definition. In the table 2:1 we can see, the term ‘energy transition’ is defined differently from each definition. ‘Transitions’ mean the process or a period of changing from one state or condition to another. The term ‘transition’ has gained increasing currency in recent years in relation to energy systems (Newell and Mulvaney, 2013). Not only in academic disciplines, it has also been incorporated into the national energy policies of some countries (Baker, Newell, and Phillips, 2014).

[6] Solar Rooftop Investment Program 2016

The concept of ‘energy transition’ is now widely used within energy studies. O’Connor (2016) describes “an energy transition—a particularly significant set of changes to the patterns of energy use in a society—can affect any step in this chain, and will often affect multiple steps” (p.8). According to Sovacool (2016) “an energy transition most broadly involves a change in an energy system, usually to a particular fuel source, technology, or prime mover” (p, 203). Sovocool (ibid) lists five general definitions of energy transitions:

Table 2:1 Definitions of Energy Transition

Definition	**Source**
A change in fuels (e.g., from wood to coal or coal to oil) and their associated technologies (e.g. from steam engines to internal combustion engines)	Hirsh and Jones (2014)
Shifts in the fuel source for energy production and the technologies used to exploit that fuel	Miller et al. (2015)
A particularly significant set of changes to the patterns of energy use in a society, potentially affecting resources, carriers, converters, and services	O’Connor (2010)
The switch from an economic system dependent on one or a series of energy sources and technologies to another	Fouquet and Pearson (2012)
The time that elapses between the introduction of a new primary energy source, or prime mover, and its rise to claiming a substantial share of the overall market	Smil (2010)

Following section delineates the development of energy transition literature over the time.

2.3.1 Energy Transition: from an historical to a socio-technical perspective on energy system change

Energy transitions from a historical perspective have been the most important elements of energy transition in human geography as well as energy study for some times. The literature on historical energy transitions have blossomed in the last ten years (see Gales et al., 2007; Geels and Schot, 2007; Wrigley, 2010; Smil, 2010; Mitchell, 2011; Kander et al., 2013). From a historical perspective, the concept of energy transition is based on the notion that a single energy source, or group of related sources, dominated supply during a particular period or era, eventually to be challenged and then replaced by another major source or sources (Fouquet and Pearson, 1998; Podobnik, 2006; Nader, 2010). This perspective focuses on the evolution of human material culture, economic growth and development, the utilization of

resources and social organisation. These literatures often follow a simple periodisation of energy history based on peak and trough of wood, water power, coal, petroleum, natural gas and so on or focus on a significant historical period: industrial era, post-industrial era or a historical event 'energy crisis' (Solomon and Krishna, 2011). Smil (2010) describes the history of modern society's dependence on fossil fuels and the prospects for the transition to a non-fossil world. The book covers global and national trends, ranging from aggregate provision of primary energies to specific supplies of individual fuels and progress of important conversion techniques. Most of the literature from a historical perspective of energy transition are a-geographical, these do not pay attention in spatial process of energy transition.

A socio-technical perspective emphasises structural innovation in energy systems (Verbong and Geels, 2007; Smith et al., 2010). This perspective mobilises a framework to provide a contextual account of technological change and understand system innovations over time. By way of illustration, a book such as Networks of power: electrification in western society 1880-1930 by Hughes (1983) is a classic example of a social technical perspective that has inspired more recent work on energy transformation. This book presents the early development of electricity system in England, Germany and the United States. A series of studies have been done by Dutch researchers Geels, Verbong and colleagues. They develop a theory for understanding the nature and rate of energy transitions, based on evolutionary economics, the sociology of technology, political economy, and other factors (Geels, 2005; Verbong and Geels, 2007; Geels and Schot, 2007; Verbong et al., 2008) which is known as a multi-level perspective (MLP). MLP is a concept that consists of three inter-linked dimensions in a nested hierarchy: (1) niche-innovations—the micro level, where new technologies (novelties) emerge and are typically protected, subsidized or otherwise promoted by government, such as bio-fuels and nuclear power. Radical niche innovations can provide the seeds for major energy system changes (Verbong and Geels, 2007); (2) socio-technical regimes—the meso level, which constitutes three inter linked dimensions, i.e.: a network of actors and social groups, formal, normative and cognitive rules, and material and technical elements. Path dependency and technological lock-in are the norm in energy systems; (3) socio-technical landscape—the macro level, which is the exogenous environment that usually changes slowly, over many decades, and influences the dynamics at the niche and regime levels (though not vice versa). These factors include the macro economy, deep cultural patterns, and macro level political developments.

Although MLP includes the macro economy, deep cultural patterns, and macro level political development through the presence of multiple actors and groups in socio-technical systems, nevertheless there are a number of limitations of this approach. It has been criticised that MLP

failed to address the agency of power struggles and cultural-discursive activities (Meadowcoft, 2009). In addition to this, according to Lawhon and Murphy (2011) MLP emphasised too much on “elite actors”, for instance technical experts and entrepreneurs and their capability of ‘guiding’ successful transitions. Hence, it gives too much emphasis on the “elite actor”, it fails to capture ordinary actors or everyday life. Baker et al. (2014) argue the way the socio-technical transitions literature sees transitions as “orderly and managed process of change”, does not reflect what happens on the ground, every time, and in all contexts. After facing criticism about lack of politics and power in transitions, some have been recent attempts to pay greater attention to the role of politics and power in transitions (see Geels, 2014; Scoones et al., 2015). However, according to Newell and Phillips (2016) “the transitions literature to date has had relatively little to say about the politics of which energy sources are prioritised, by whom and why, and what this means for who secures access to energy” (p. 40). Newell and Phillips (ibid) add ‘there is a growing recognition that ‘regime resistance’ (Geels, 2014) matters, and that governments need to exert authority over market actors to initiate more rapid transitions without detailed attention to the political processes and terrain upon which they play out’. No doubt about identifying diverse institutional contexts that give rise to very different forms of decision making and power asymmetries that may influence sustainability trajectories in different ways (Hansen and Coenen, 2015; Kern, 2011; Kuzemko et al., 2016), but it also requires us to develop specific accounts of the politics and political economy of contending energy pathways in particular contexts (Newell and Phillips, 2016).

A further illustration of the socio-technical approach to energy systems, which explicitly engages questions of social power is, *Carbon Democracy* (2011) by political scientist and historian Timothy Mitchell. This book is unconditionally important to mention. The book presents the interlinked history of coal and oil in the United States, the United Kingdom, and the Middle East. Exploring the properties of oil and the networks along which it flowed, the book provides an in-depth examination of the relationship between politics, democracy, and energy sources. Throughout the book, Mitchell develops a series of questions such as, ‘how can forms of political life be created from the production and consumption of large amounts of hydrocarbons? Can such formulation provide the basis for a materialist theory of politics? What happens to the materialist conception of politics when the physiochemical properties of matter become constitutive of political agency? With this book, Mitchell opens a new door to a “socio-technical understanding” of democracy as a form of political life grounded in forms of carbon energy and capturing politics of global energy transition. Although *Carbon Democracy* first developed within political science, it has become a key point of reference for work on the politics of energy transition within social science (Luque-Ayala, 2016).

It is true that a number of researchers have used experiences of diverse geographical locations from past energy transitions to inform the present and future policies (Sarrica et al., 2016; Sovacool, 2016; Andrews-Speed, 2016; Pearson, 2016). The literature of socio-technical perspective of energy transitions, however, tends to be confined to Western Europe; only recently some of the scholars are trying to shift their focus in Asia. In 2009, a special issue of Technological Forecasting and Social Change posed a question about sustainability transition in developing Asia. Later, Berkhout et al. (2010) applied MLP to Southeast Asia in understanding the palm oil biomass waste to energy niche in Malaysia and its international linkages (Smits, 2015). In summary it can be said that, socio-technical transitions theory not only falls short in providing adequate 'tools' to analyse politics and power dynamics between heterogeneous actors but also it also lacks grounding of transitions in geographical contexts on uneven development.

2.3.2 Political Economy of Energy Transition

In a paper Baker et al. (2014) argue "energy transitions need to be attentive to the diversity of economic, political and social contexts in which transitions need to, and to some extent are starting to occur, if they are to retain relevance outside of the high-income country settings in which many of them were developed" (p 24). Comprehending the pressing need to address poverty and social inequality in South Africa, Baker et al. (ibid) encourage energy transitions to incorporate political economy literatures to conceptualise energy governance. According to Baker et al. (ibid) fusion between energy transition and political economy literature will help to unpack the power relations inhibiting and enabling change in other countries where the challenges of promoting a low-carbon transition are every bit as acute as in South Africa.

The political economy perspective provides a lens through which to engage with a set of theoretical perspectives that connect us to a better understanding of donor-driven development programmes which leads the national political context (ibid) . The key political economy questions of 'who wins, who loses, how and why' as they relate to the existing distribution of energy, who lives with the side effects of its sites of extraction, production and generation, and who will bear the social costs of decarbonising energy sources and economies (Newell et al., 2011; Newell and Mulvaney, 2013). As an analysis of political economy perspectives emphasizes the importance of history, the role of politics, social relations of production, international economic structures, and the relationship between capitalist development and economic changes, it shapes this research by challenging the relation between energy transition and development.

Political economy of energy transition is a vastly understudied area (Goldthau and Sovacool, 2012). Realising the need to foreground social processes and power relations in transitions research (Lawhon and Murphy, 2012), recently a growing body of literature are now focussing on how the nature of energy transitions is strongly influenced by the process of neoliberalisation[7] that shape energy policy in the global South. Newell and Phillips (2016) emphasise global political economy of energy transition where configurations of power between states, donors, and transnational capital have distinct characteristics that have not been captured by Eurocentric socio-technical transitions literature. According to Newell and Phillips (ibid) "a transnational reading of political and social relations – embedding domestic energy politics within global policy networks and circuits of power – illuminates the critical and contested role of the state in neoliberal energy transitions" (p. 39). In this paper, Newell and Phillips state clearly "neoliberalisation not as an end state, but rather as a contested and spatially and socially uneven process through which ever more areas of political life are subject to market discipline which increase the dependence on private actors for the provision of public goods (ibid). This literature provides useful insight for the research as transition of solar energy is an outcome of electricity sector reforms that involves a number of entities that shapes this transition.

The commercialisation of household-level low carbon energy technologies being installed across communities throughout the Global South. A very strong emphasis from the development industry on the role of the private sector in accelerating developments have encouraged international and local businesses and NGOs supplying low carbon energy products, innovating new business models (Brown and Cloke, 2017). Scholars (such as Gent and Tomei, 2017; Jewitt and Raman, 2017; Marshall et al. 2017) argue that these kinds of new technology interventions the socio-cultural impacts on people's life. Thus a call for a more careful evaluation of the dominant market-focused approach towards low carbon energy transitions to the contested governance of low carbon energy transitions (Brown and Cloke, 2017) is being made.

2.3.3 Towards a spatial Perspective of Energy Transition

Over the last decade, there has been an increasing interest in the field of energy as a spatial problem. Many have pointed to the importance of understanding energy transitions as social and spatial processes (Calvert, 2016; Huber, 2015; Rutherford and Coutard, 2014). In a

[7] Neoliberalism is a political theory of the late 1990s holding personal liberty is maximised by limiting government interface in the operation of free markets. It is an economic ideology based on promoting "rational self-interest" through polices such as privatisation, deregulation and globalisation.

seminal paper Bridge et al. (2013, p. 231) call for interventions that seek to examine the spatial organisation and governance of new energy systems, and to generate new ways of thinking about energy transition as a spatially-constituted process "involving the reconfiguration of current patterns and scales of economic and social activity". Some scholars have given emphasis to develop an understanding of energy transitions as uneven social and spatial processes (Calvert, 2016; Huber, 2015; Rutherford and Coutard, 2014). These processes involve the 'reconfiguration of current patterns and scales of economic and social activity' (Bridge et al., 2013: p. 331), in which 'people and places unevenly experience the costs and benefits of energy extraction, generation, financing, distribution and consumption' (Newell and Mulvaney, 2013: p. 4). These literatures have helped to address the neglect of power and social relations that configure questions of energy access and energy justice, and suggest important starting points for analysis of the specific features of colonial and post-colonial socio-technical energy systems that have developed in the South.

In the earlier section, I pointed out socio-technical literature did not pay much attention on the energy transition in the global south. Bradshaw (2010) in his Global Energy Dilemmas: a geographical perspective thesis differentiates 'the problem' of energy by different parts of the globe – different trajectories and destinations of transition. Spatial perspective to energy transition literature has emphasised on not only the uneven social and political process of energy transition, but also extended its focus from high carbon to low carbon energy transitions (Brown and Cloke, 2017). Scholars acknowledge that in parts of the global South, energy transition implies a significant increase in the availability and affordability of modern energy services and, in some particular contexts, this may also mean an increase in carbon intensity (Bridge et al., 2013). Bouzarovski (2009) argues in the 'transition economies' of Central Europe and the former Soviet Union energy transition is framed primarily as a 'liberalisation' of the energy sector with key changes occurring in the structure of ownership and the role of competition. These literatures open up the door for multi-scalar and geographically constituted energy transition debates by paying attention to scale and space of energy research which was missing in both historical and socio-technical perspective of energy transition.

A burgeoning number of scholars have written about the importance of spatiality of energy transition. Castán-Broto and Baker (2017) who turn to spatial adventure for understanding the spatiality of energy transition, identify a relational perspective as critical to analysing the provision and use of energy. Inspired by Doreen Massey's ideas of space as a relational, as a container of social life, Castán-Broto and Baker (2017) see energy transition "as a negotiating ground not just to secure energy access and move towards sustainable energy systems, but also to make explicit how we know and understand these problems" (p. 2).

Massey argues there are three propositions of space: first, space is constituted through interactions; second, space is 'the sphere of possibility' that facilitates multiplicity, distinct historical trajectories, and coexisting heterogeneity; third, space is performed and actively constructed, always in the making, unfinished (Massey, 2005; Bridge, 2017). Thus, the idea of energy transition as a relational space recognises that energy transition of a given context is actively constituted through social and material relations, and thus, it is an unfinished project, characterized by its multiplicity. It not only provides an understanding of the co-construction of space and social life, but also calls to develop a thinking that space is not a pre-existing, fixed, category as McEwan (2017) believes energy transitions is simultaneously spatial and political processes that is not fixed in any category.

Bridge et al. (2013) who started the conversation of spatial turn in energy transition along with Calvert (2016), attempts to delineate a coherent core of central themes that the current field of spatially sensitive energy research has developed (Bridge, 2017). In this paper, Bridge (2017) admits the full potential of a spatial perspective on energy studies is not fully developed. Here he proposes three generative themes as proposals for future research: the decolonisation of energy geographies through an understanding of geographies of knowledge production about energy; the differentiation processes at work in the making of energy territories; and the processes of destabilization that actually challenge incumbency (*ibid*). Agreeing with Bridge, this research emphasises on the uneven social consequences of energy transitions, it believes we still require an account of the politics, power and social relations that produce those outcomes: an account of why the organisations of energy systems privilege some actors, interests and classes over others, as part of a broader account of how political economies influence energy transitions.

Myriad literature has been written about low carbon energy using examples of the North and the South. Whilst debates around low carbon energy transition in the north are mainly concerned about sustainability and energy security for the future, in the south this is more about energy access (Bridge et al., 2013), a concern about present development. Low carbon energy transition in the South is access to modern energy for the development where transnational actors have been actively involved in creating the neoliberal market conditions under which renewable energy development has proceeded in the developing countries. From this perspective, low carbon energy transitions are therefore not only about energy, or even geography, they are about how power infuses the relationships between energy, politics, and the spatial transformations associated with transition (Rignall, 2015).

Science and Technology Studies scholarship has argued that the material powers of energy matter that energy is not a neutral resource, but that particular powers shape particular

societies and social orders (Hughes, 1983; Nye, 1990; Hecht, 2009; Mitchell, 2011). Using these ideas, Turner (2016) who conducts research in UK and Sri-Lanka, argues that solar energy is not a neutral resource but rather is a spatially and temporally diverse force with properties and propensities, which encourage particular orderings of meaning and matter. A number of socio-political imaginations have been influential for solar energy transition in the developing world. In the article the 100th objects: Solar lighting technology and humanitarian goods, Jamie Cross (2013) describes how solar lantern is presented as a humanitarian good in a joint exhibition of the British Museum and the BBC radio. Cross (2013) argues solar energy as a humanitarian good is not 'solely a result of the way it particularly works, but because the solar lantern is capable of assembling a number of concerns and interests, politics, moralities and ethics' (Cross, 2013: p. 369). Influenced by this new socio-political imagination, solar energy appears as life changing tools of development that the poor need to have in their life if they want to change their life. Cross (ibid) concludes Bottom-of-the-pyramid markets in Africa and Asia for things such as solar energy does not emerge: they are made, and this thesis problematizes the process of making a solar energy market and its 'intended' and 'unintended' consequences on business and people's lives.

2.4 **Conceptual Framework**

This research adopts a spatial approach to understand the process and experience of a solar 'energy transition' in the global South. It highlights the differentiated outcomes of solar in urban and rural areas in Bangladesh and, in particular, the different ways in which solar is integrated into daily life in on-grid and off-grid areas in the country. By giving attention to the spaces and places, this thesis adopts the energy transition framework that transition to a low-carbon economy is produced rather than as a process that affects places. The conceptual framework this study uses as Bridge et al. (2013) suggest "low carbon transition as a simultaneous process of geographical equalization and differentiation that has the potential to produce new patterns of uneven development" (p. 317). According to Bridge et al. (ibid), understanding transition as a geographically constituted process has three implications for energy policy. Firstly, spatial difference and the fundamentally uneven nature of spatial interactions are both potentially disruptive to policy because they complicate many of its assumptions: understanding the way these interactions and interrelations can enable or frustrate policy goals is therefore of practical value. Secondly, space is a necessary condition for the possibility of multiple, co-existing energy pathways and, therefore, an important source of variety and experimentation: there are significant opportunities, therefore, for understanding the relationship between different trajectories of energy transition and the geographical conditions from which they emerge. Thirdly, it highlights how implementing a low- carbon economy will be a simultaneously creative and destructive process that significantly changes

how different places are related to each other, economically, politically and even culturally, and at a range of different scales (p. 339).

The thesis extends existing debates in energy transition with expositions from the political economy of low carbon energy transition. The political economy provides a lens through which to engage with a set of theoretical perspectives that connects us to the better understanding of donor-driven development programme which leads the national political context (Baker et al., 2014). As an analysis of political economy perspectives emphasizes the importance of history, the role of politics, social relations of production, international economic structures, and the relationship between capitalist development and economic changes, it shapes this research by challenging the relation between energy transition and development. The key political economy questions of 'who wins, who loses, how and why' as they relate to the existing distribution of energy, who lives with the side effects of its sites of extraction, production and generation, and who will bear the social costs of decarbonising energy sources and economies (Newell et al. 2011; Newell and Mulvaney, 2013). This framework helps this research to understand the relation between the state, NGOs, market actors and international donor organisations.

While the literature on spatial understanding of energy transitions provides useful insights into the drivers of change and the actors that have to be on board for technologies and mode of production, the political economy of transitions brings the exercise of power by state and corporate elites that shapes a process of energy transition. Where both spatial perspective and political economy of energy transition often fall short to understand impact of energy transition on people's everyday life. Everyday life is the observable manifestation of social existence that makes social life visible (Sztompka, 2008). In energy research, energy is seen an invisible material (Lutzenhiser et al., 2009), it can only be visible when we focus on 'visible use of energy', 'materials practices', 'process', 'technologies' and 'persons' that consume energy (Pink, 2011). This thesis argues, everyday life helps to understand the impact of any development programme, as there is a tendency of development literature to emphasise the outcome of a development programme. The way people are living with new technology or the transition of becoming a part of new technology is essential to understand. An attention to the "the lived experience" of energy and development is required to understand the "choices and fundamental changes in the daily lives of already disadvantaged" people (Harrison and Popke 2011: p. 959). Acknowledging the importance of these issues, this thesis focuses on how energy transitions and development interventions play out in people's everyday lives. Therefore, this thesis argues in understanding energy transitions, we need to make a link between transnational politics to everyday politics of low carbon energy transitions.

2.5 Conclusion

This chapter has presented a narrative explaining the emergence and journey of the research's analytical framework. I have presented and discussed the key literature and conceptual framework of the thesis in three distinct steps. First, the chapter examined the scholarly literature on energy for development and energy transition within human geography and associated disciplines. Second, the chapter recognised a gap in the contemporary literature, but also acknowledged those parts of the literature that have been sources of inspiration shaping this thesis. In particular, it explained how post development literature and literature on everyday life have help this research to bring a critical voice and advance in-depth understanding of the geographically constituted energy transition process.

In this chapter, I have argued how the energy for development literature is generally rather uncritical. Much of the literature is concerned about either the diffusion of solar energy technology or technical solutions. This literature largely ignores users' perspectives and their daily life with this low carbon energy. In this chapter I have suggested that we need to pay attention to the perspectives of technology users by engaging with their everyday life. I have also suggested that space is very important for energy research. In particular, I have drawn attention to how the process of energy transition in urban areas is different from rural areas, and how the experiences of low carbon energy transition in urban areas in the global south are an understudied topic. Therefore, we need to pay attention to spatial differences between urban and rural areas and their respective energy landscapes. To address this issue, I have argued that the literature on spatial understanding of energy transitions provides useful insights into the drivers of change and the actors that have to be on board for technologies and mode of production. Despite having great scholarly contribution, this literature falls short of providing an in-depth analytical framework to understand micro politics such as class, gender relations and family dynamics.

Overall, then, this chapter has laid down analytical foundations for the thesis. The following chapter outlines how this thesis has translated these insights into a methodology aimed at developing an in-depth understanding about solar energy transition in Bangladesh.

Chapter Three: Methodological Reflections

Figure 3:1 Learning about everyday life of solar energy users over stitching a katha[8]

[8] *Katha*: traditional throw made from thin cotton clothes

3.1 Introduction

This chapter explains the process and methods used to carry out the research. It has been noted that researching energy is a complex job because, while energy itself is invisible (Lutzenhiser et al. 2009), it has highly visible social-economic and political effects (Nye, 1998; Mitchell, 2009). Researching low-carbon transition in the Global South includes not only multi-scale local and global actors but also a flow of discourse, ideas, power and resources. In Bangladesh, for example, the roll out of solar technologies is a combined influence of the *Global Agenda's Sustainable Development for All* 2013 (SDG#7) and the local agenda *Electricity for All* by 2021 which is highly inspired by the development discourse, i.e. economic growth, women empowerment and become a middle-income country. In short, solar energy transition in Bangladesh involves multiple sites and actors who are active across multi-scale. Thus, this study adopts an ethnographic approach across multiple sides (Marcus, 1986; 1995). Many critical international development scholars (see Bebbington and Kothari, 2004; Roy, 2009) endorse multi-sited ethnographic approaches for development-focused research where the location of this work is not based on a single organisation or bound localities. As discussed briefly in Chapter one, solar energy transition in Bangladesh is a combination of influences from the global Agenda Sustainable Development for All 2030 (SGD#7) and the local agenda Electricity for All by 2021. It is highly inspired by the development discourse, i.e. economic growth, women's empowerment and the journey towards being a middle-income country. Thus, examining the solar energy transition in Bangladesh encompasses multiple sites, multi-scale actors, distinct ideas and technology, which requires a flexible and fluid approach.

Previous geographical research on energy transition has predominantly focused upon the socio-technical aspect of energy (discussed in chapter two); and only recently has the "people-oriented" research agenda begun to receive attention (Castán-Broto et al., 2017). Furthermore, the majority of these research studies (even if they do not focus on the socio-technical aspect), fail to detail the impact of low-carbon energy on people's day to day lives (Kumar, 2015). These studies tend to concentrate on macro-politics by focusing on policy, governance and the elite (Baker, 2015); and use interviews as a research method. Thus, they are not able to adequately understand the micro-politics of 'ordinary' people whose lives have been so affected by this energy transition and newly formed policy (Kumar, 2015). As this thesis' aim is to investigate how people in on-grid and-off-grid areas manage their everyday lives with solar energy (RQ. 2) and to what extent solar energy interventions work to achieve particular development goals (RQ. 3), this thesis posits that only details of information about people everyday lives will help the research to answer these research questions. It is argued that energy's invisibility can be made visible by focusing on 'materials practices', 'process', 'technologies' and 'persons' that consume energy (Pink, 2011). Therefore, to develop a

detailed, in-depth understanding of solar energy transition in on-grid and off-grid life as well as the everyday operations of the solar energy market, a multi-sited ethnographic approach was chosen.

The chapter reflects on the research methods employed and on what could be learnt from the process. This chapter has four sections: in the first section (Section 3.2), I focus on the pre-fieldwork period when detailing the initial influences that shaped my fieldwork. Then, the chapter moves to explain the actual process of carrying out fieldwork Narsingdi, Sandwip and Dhaka (Section 3.3). In Section 3.4, I describe the methods that were chosen for this research and what I learned from this process. The chapter concludes by reflecting upon some critical issues that this research and myself as a researcher encountered during the fieldwork (Section 3:5).

3.2 Before the journey commenced: The pre-fieldwork period

3.2.1 Photovoltaics for Future Societies

This PhD research is part of an interdisciplinary research project funded by The Engineering and Physical Sciences Research Council *(*EPSRC*):* Photovoltaics for Futures Societies EP/I032541/1. As a part of the research proposal, the project aimed to explore the future of photovoltaic solar energy across two sites in two different countries: Sheffield (England) and Dhaka (Bangladesh). However, due to some internal difficulties of the research team and political uncertainty in Bangladesh, the larger team never made its way to Bangladesh. Therefore, the project moved from a comparative study to an individual country study and I had the scope to come up with my own proposal and carry out a different, but complementary project from that initially designed. Knowing that the nature of the low-carbon energy transition is uneven (Bridge et al., 2013) and path-dependent (Sovacool, 2016), my aim was to capture the flow of an ongoing geographically-constituted energy transition in Bangladesh. However, when I started the fieldwork in on-grid areas in Dhaka I realised that rather getting insight into how people *are* using solar, I was getting more information on how people *are not* using solar: I gathered more data on all the possible ways people avoided solar energy and why they did so. As with the rural areas, I assumed I would collect data as to how people use solar energy in urban areas in a different way to those in rural locations; I did not realise that I would get data suggesting people in on-grid areas are not using it. Therefore, methodologically my research had to be flexible and fluid to cope with the changing nature of the data and momentum of the on-going energy transition in Bangladesh.

3.2.2 Becoming an energy social scientist

I spent half of my first year of the PhD process at Sheffield University, learning about the technical aspects of solar energy. I had a series of meetings and workshops with the team members of Photovoltaic for Future Societies. We also met with project members to keep people up to date with the direction of our research. It was a mutual learning process where both social scientists and applied scientists came together and discussed the future of photovoltaic solar energy. In the first year of the project, the team members read and exchanged views on previous studies of science and technology. We read Callon's (2009) Acting in an Uncertain World, Latour & Woolgar's Laboratory Life: the Construction of Scientific Facts (1976), Latour's (1987) Science in Action and we exchanged our views on these books. I presented several times to inform the team members of the context and current situation of solar energy use in Bangladesh in order to help shape the project's future plans and fieldwork phase as well as presenting key findings to the team members in different stages of this research.

Figure 3:2 Photovoltaic for Future Society team's monthly meeting in Sheffield University. Source: Research team archive

The meetings that I had with my colleagues at Sheffield University helped me to gain confidence in the fundamental aspects of photovoltaic solar technology. It is important to

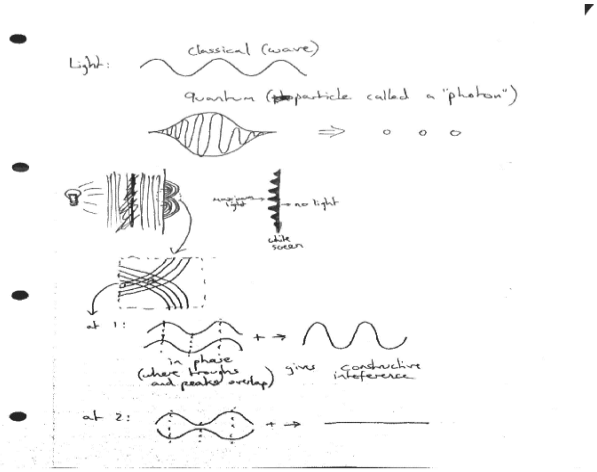
mention here, that throughout my field work I had to justify and convince many of my respondents that I knew how photovoltaic solar technology works without having a degree in engineering. During my fieldwork, I was pleased that being part of a collaborative team meant I learn a lot from my colleagues and that helped me to demonstrate my knowledge in front of solar energy experts.

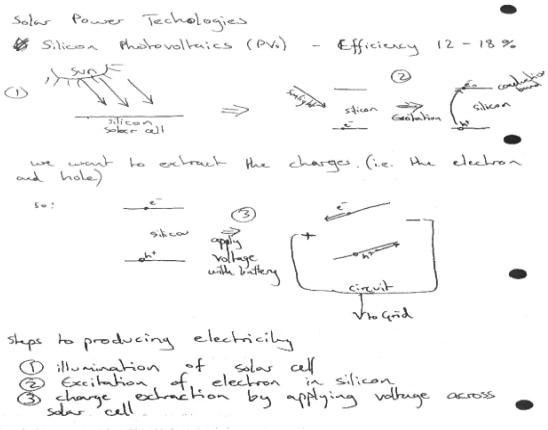
Text box 1: Process of becoming an energy social scientist, learning about photovoltaic solar energy from colleagues

Research Diary 05/11/2011

Process of knowing unknowing what does this mean??

It has been a month since I started my PhD programme. My research is a part of an interdisciplinary project with collaboration between physicists, engineers, geographers and architect. Tomorrow I am going to meet other project members. I already knew the geographers participating in this project but I don't know any other "scientists" in this group. I am a little bit nervous as this PhD is about the future of photovoltaics, but I don't know anything about solar energy or how it works. I have only studied social science throughout my life; I have never studied even the basic theories of physics. I started my PhD in a technical subject where I do not have any disciplinary background. How I am going to communicate with them? I actually started learning from a very basic level how solar energy works. I spent several days with my housemate who a mechanical engineer is doing PhD at Sheffield University, who has taught me basic knowledge about photovoltaic solar energy. For me it is a whole new world, which is interesting and scary as well because I am not sure much do I need to know about the technical aspects of photovoltaic solar energy. At one point, even my housemate asked me how much detailed technical information does a social scientist required to work on a technical subject? It seems like even I am not sure how much I need to know to study the technical aspects of solar energy!





Nast (1994) argues that the 'field' is not naturalized regarding 'a place' or ' people'; it is instead located and defined according to specific political objectives that cut across time and space. Although officially my fieldwork started in October 2012, for me the fieldwork started even before I went physically to the selected physical field sites. I had an opportunity to meet some of my interlocutors when I went to a conference at Loughborough University in April 2012, where a total of ten energy experts came from Bangladesh to discuss energy issues. In the conference, two aspects struck me: firstly, the gender imbalance among energy experts from Bangladesh; among the ten Bangladeshi energy experts, there was only one female who was an architect by training. The rest were male. Secondly, there was not a single Bangladeshi social scientist at that conference. When I introduced myself as an energy researcher with a background in Anthropology and Human Geography, local experts were surprised that I did not have a degree in engineering and yet I was researching technology. Meeting energy experts from Bangladesh made me realise that energy research in Bangladesh is still considered as the domain of technical experts and is still a male-dominated area of study. In those two days at the conference, I gathered a great deal of information without going to the field physically. It also helped me to build a rapport with the local scholars and highly-placed officials who were working in the energy sector in Bangladesh.

3.3 **Following the network: a fluid approach**

As previously mentioned, initially my research was part of a larger interdisciplinary research project, thus much of the early reading and designing of the given study was influenced by STS literature. I drew the following map (Figure 3:4) of the solar energy network in Bangladesh based on secondary and grey literature on solar energy in Bangladesh influenced by my initial reading about science, technology and society. In putting the solar PV at the heart of this network, I tried to identify the relevant actors of this network. The network had some heterogeneous elements that involved not only humans or organisations but also different non-human actors: for instance, technology, equipment, locations and also values and discourses. The exercise was useful as it revealed a messy and complex relational space that helped me to choose a fluid and flexible research approach.

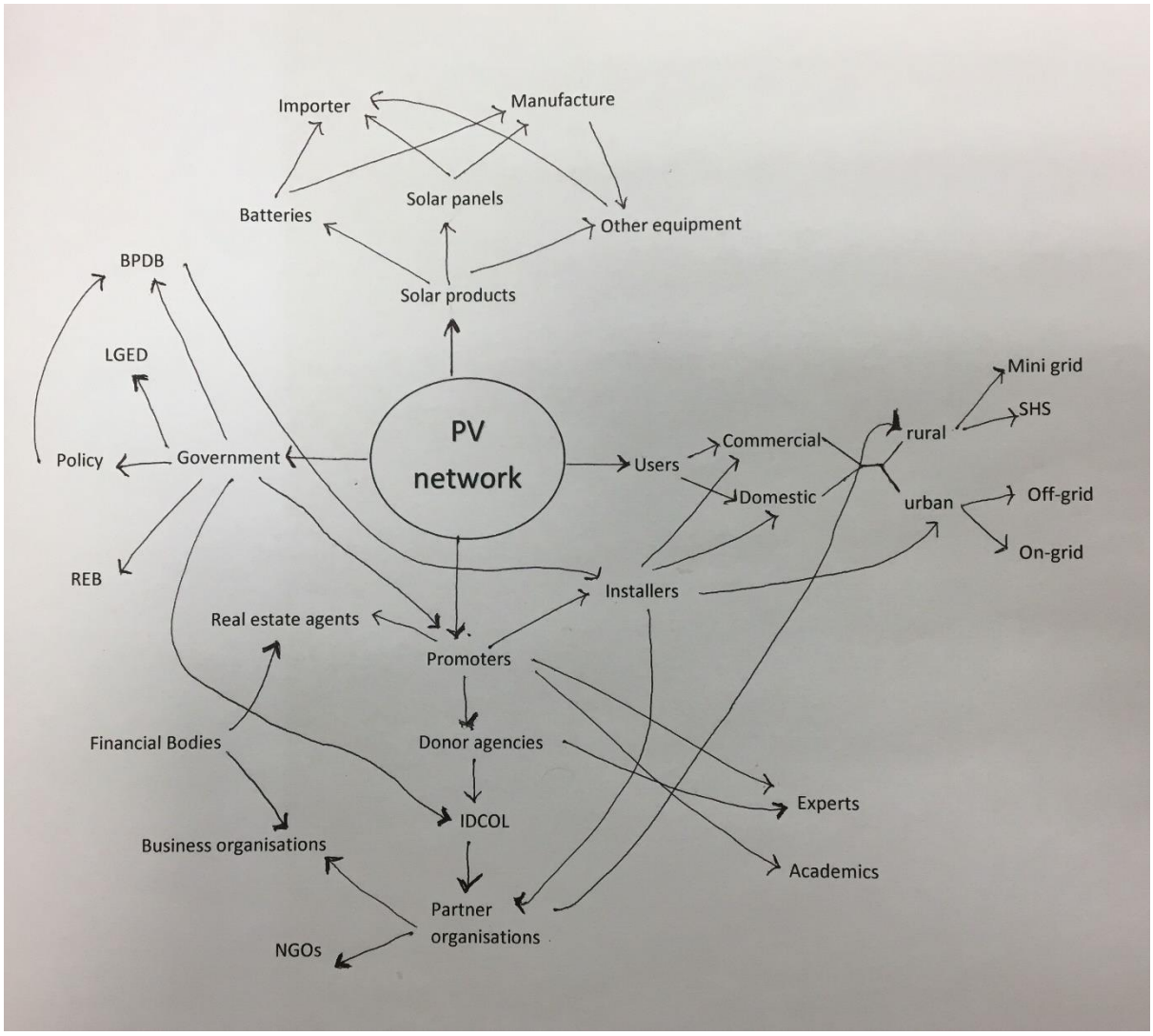


Figure 3:3 Map of solar energy network outlined by Author

This map gave me an overall picture of the solar energy transition activities and the evolving network. Taking this map (Figure 3:3) as a guiding tool, the study uses the ethnographic approach to reveal the processes and meanings which underpin social and political action (Hebert, 2000). According Brewer (2000) “ethnography is not one particular method of data collection, but instead is a style of research that is distinguished by its objectives, which are to understand the social meanings and activities of people in a given ‘field’ or setting”, and its approach involves close association with, and often participation in, this setting” (p.11). For this research, ethnography is not just a method; it is an approach that helps to cultivate a particular understanding of a geographically constituted relational space (Castán-Broto and Baker, 2017) where low carbon energy transition is in progress (Bridge, 2017). Thus, ethnography provides an in-depth insight of process and meanings; it can most clearly

illuminate the relationships between structure, agency and geographic context (Hebert, 2000). Besides, the transition of low carbon energy in the Global South involves not only multi-scale local and global actors but also a flow of discourse, ideas, power and resources.

Over the last two decades, multi-sited ethnographies have become an increasingly common approach to social scientific research especially within studies focussed upon the movement of people, objects and ideas (Appadurai, 1986; Stoller, 2002). A multi-sited approach enables us to study the field as a network of localities which are linked to each other through various types of flows. What has emerged is a richer understanding of the various webs of relations between technology and people; relations between ideas and polices; relations among different organisations and processes of creating a market for solar energy. By following the everyday life of solar energy users (Chapter Six), methods of the ethnographic approach (as will be discussed later in Section 3.4) and the relationship between technology and users, have inform this research, allowing me to explore how people live with solar energy, and the impact of the solar energy transition in the on-grid and off-grid areas in Bangladesh. Everyday market experiences allowed this research to explore the politics between the state and different kinds of national and international organisations, as well as power relations between the state and donor agencies (Chapter Five).

3.3.1 Entry points

Taking the map of the solar energy network in Bangladesh as a guiding tool, this research selected four entry points to understand the solar energy transition in Bangladesh. According to Ruming (2009) entry points positions the actors as the starting point of a more thorough network tracing exercise that helps a research to explore a diversity of other interested (human and non-human) actors are scattered through the network. Choosing entry points was a difficult job because a number of activities have ongoing to make solar energy technology fully integrated into electricity network. Initially six entry points were selected, including a solar irrigation programme and solar streetlight. Considering the limited duration for fieldwork, I narrowed the research focus down to four entry points and kept the focus mainly on solar energy transition at household level and its market. Rather than going with a pre-selected list of informants, having entry points helped this research to combine places, technologies, policy and programmes. While the entry points have proven useful as it allowed my research to be fluid and gathered a wide range of data, it nonetheless has some disadvantages. For example, during my fieldwork I realised that while entry points had given me access to a network of solar energy technology, it did not give *exit* point; a researcher needs to decide upon an exit point based on practicality and value of the gathered data. On several occasions my chosen entry points led me a route that involved travelling beyond Bangladesh, yet considering the scope

and practically of this research, I decided to keep this route to only in Bangladesh. The entry points are as follows:

- Narsingdi Solar Energy Project
- Sandwip Island
- Urban Rooftop Solar Energy policy
- Solar Energy Market

Narsingdi Solar Energy Project

The first entry point of my fieldwork was a pilot solar energy project which is considered as a landmark in the history of Bangladesh. Narsingdi solar energy project was initiated in 1996 by the French government with a grant of 6.4 million French Francs and a local contribution of about 26.30 million Taka from the government of Bangladesh. The project was installed on Nazarpur and Karimpur islands in Narsingdi, a district situated in central Bangladesh where various categories of solar consumers were targeted to be provided with electricity.

The reason for choosing the Narsingdi solar energy project as a first entry point was because it was the first large scale solar energy project in the country, and thus would allow this research to gain an in-depth understanding of the history of the emergence of photovoltaic solar technology and how the situation has changed between then and the present day. More importantly, the Narsingdi solar energy project was significant as an entry point for this research as it is concerned with exploring how solar energy emerged and developed in the Bangladeshi power and energy sector (RQ 1).

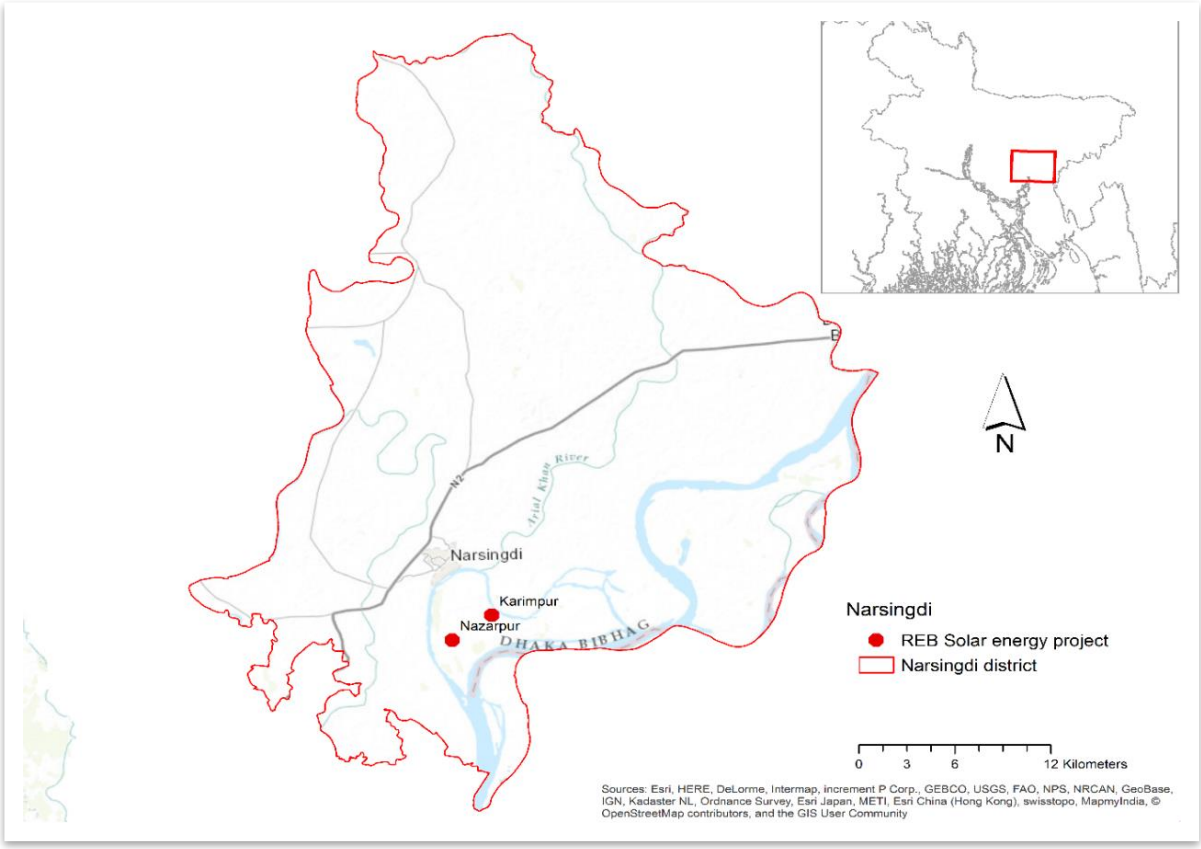


Figure 3:4 Map of Narsingdi solar energy project (source: ESRI, 2017 modified by Pammi Nitin Sinha)

Thus, I was curious to learn why this project was located in Narsingdi. It appears that Narsingdi is one of the nearest locations to the capital, Dhaka (which is around 60km away), which the national grid connection failed to reach because some areas are disconnected from the main land (Figure 3:4). However, when I went the islands of Karimpur and Nazarpur for fieldwork, I learnt that the then Minster of Power and Energy was from Narsingdi district; thus there had been a longstanding demand from the villagers for the ministry to bring electricity to the villages within the area he represented. I had initially planned to spend four weeks exploring the history of the emergence of solar through the Narsingdi solar energy project. I realised however, that no one is currently using solar energy on Karimpur and Nazarpur, as the project halted operation within two years, when the villagers received connection from the Rural Electrification Board.

Finding accommodation was difficult on Narsingdi (as will be discussed in section 3.6). Therefore, I had to travel for more than three hours each way, every day, from Dhaka to Narsingdi. After spending two weeks commuting from Dhaka, I realised that it is difficult to find former users of solar energy who can talk about something that existed more than a decade

ago. From this short period of field data, I learnt that the people of Nazarpur and Karimpur were not happy when the project was initiated, as solar energy was not deemed to be "proper electricity"[9]. It was therefore difficult to find people who were interested in talking about their experience of solar energy. Consequently, I decided to shorten the time for this entry point and start planning for the next entry point.

Figure 3:5 Former solar panel station in Narshingdi. Source: Author

Sandwip Island Entry Point

The second entry point of this research was Sandwip island, situated along the south eastern coast of Bangladesh in the District of Chittagong. Sandwip island is situated at the estuary of the Meghna River on the Bay of Bengal and separated from the Chittagong coast by the Sandwip Channel (Figure 3:6). The island is 47 kilometres long and 5-15 kilometres wide. There are 34 villages on Sandwip Island and it has a population of nearly 350,000. According to local people, the original size of Sandwip Island was 472 sq km; but due to river erosion, the island has been shrinking and now it is only 66 sq km. Thus, geographical adversity has always been a main hindrance when it comes to the question of any infrastructural

[9] The villagers had given a derogatory name for solar lights i.e. Balloon Batti (Batti means light). According to a researcher who worked as a consultant to evaluate the project told me that there was a protest on the project inauguration day, where the villagers demanded that they "want proper batti, not this balloon batti".

development. Although the Narsingdi solar energy project was the first large scale solar energy project in Bangladesh, Sandwip has the oldest legacy, as a small-scale pilot project was installed in Sandwip in 1987 by the Atomic Commission of Bangladesh.

As an entry point, Sandwip was chosen not only for its longstanding history, but also for the variety of types of solar energy programmes that can be found on the island. When I was doing fieldwork, Sandwip was the only place where one could study both the solar home system and the solar mini grid, as the first solar mini grid project (Purobi Mini Grid) was implemented on Sandwip in 2009 by a private organisation with combined support from several international donor organisations such as the World Bank (WB), Kreditanstalt für Wiederaufbau (KfW) and The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ). According to the local people, 50% of the households use solar energy (although there is not any official record regarding this claim). Thus, Sandwip island was an exceptional location where I could investigate the everyday life of off-grid people and gather data about multi-scalar diverse actors and activities by exploring both solar home systems and the solar mini grid programme.

Table 3:1 Three types of solar energy network were found in Sandwip

Name	Working area	Technical support	Fund
IDCOL solar home system	All over Sandwip	Local and imported product	Various funding comes through the state-owned bank IDCOL
Purobi mini grid	Enam Nahar,	German	World Bank loan, KfW grant and private ownership
Retail solar home system	All over Sandwip	Local and imported product	Local small entrepreneurs with personal loans

I spent four months on Sandwip Island. This entry point allowed me to explore the everyday life of off-grid people who live with little electricity or no electricity and manage their day to day energy needs through a variety of energy sources. This entry point also gave me an indication of wider applications of solar energy in different off-grid situations, together with the everyday market experience of solar energy transition in Bangladesh.

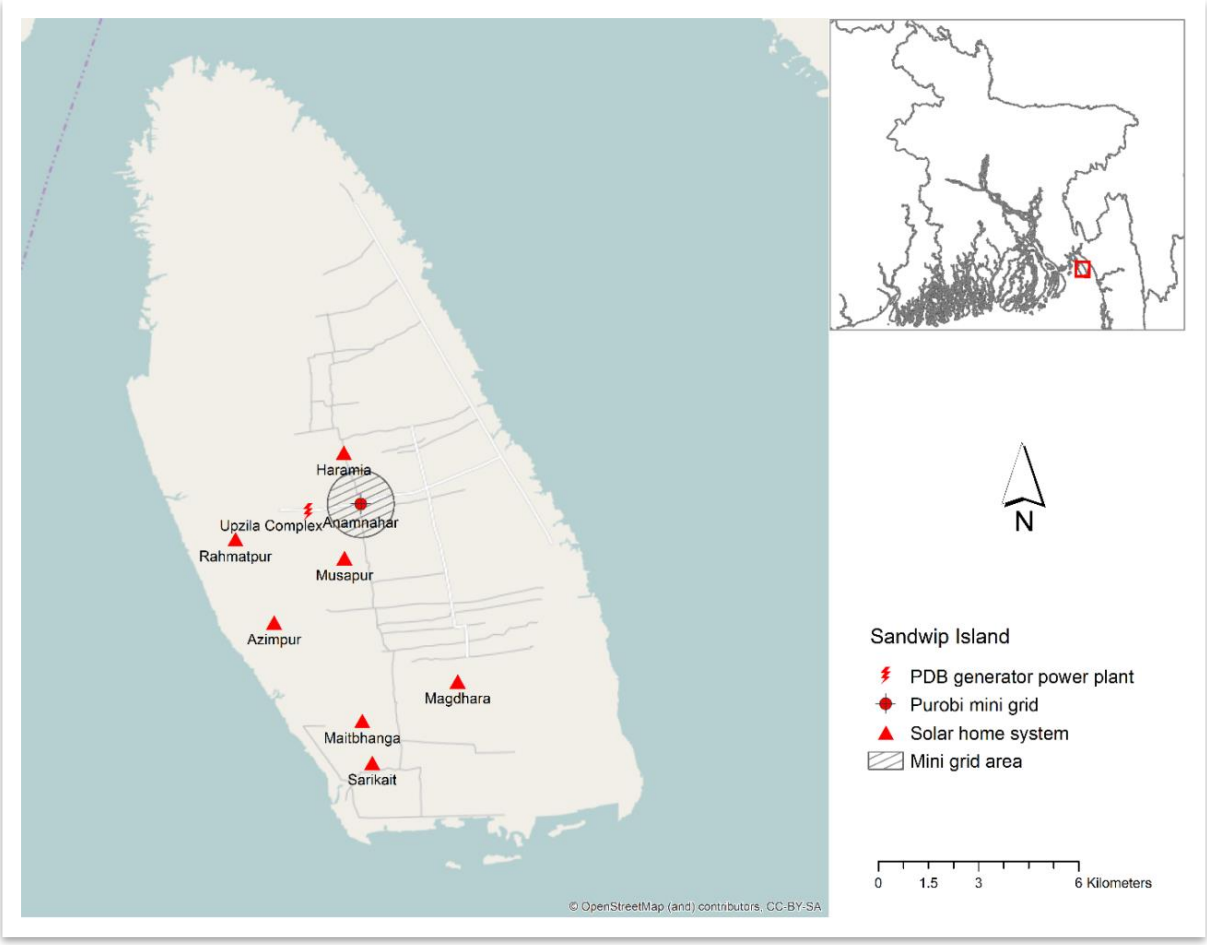


Figure 3:6 Map of Sandwip island entry point. Source: Open street map, modified by by Pammi Nitin Sinha

Urban Rooftop Solar Energy Policy

The third entry point selected for the fieldwork was Dhaka, the capital city of Bangladesh, which allowed me to explore the impact of the urban rooftop solar energy policy. There were two reasons for choosing to conduct this research in Dhaka city. Firstly, urban expansion in Dhaka is exponential (Offfer et al., 2011), and this massive expansion could offer exceptional information that no other city in Bangladesh could offer. Secondly, the majority of NGOs, private organisations, international donor organisations, as well as the power ministry, have their headquarters located in Dhaka. Thus, Dhaka provided a fruitful setting in which to explore the impact of the solar energy policy on high-rise building rooftops, as well as to explore answers to questions that Sandwip failed to answer about solar energy expansion in rural areas.

To explore the everyday life of solar energy users in high-rise buildings (RQ2), I carried out fieldwork in newly-developed residential areas named Mirpur DOHS, Bashundhara and Uttara. I also, travelled to other locations in the city to interview officials from different NGOs and the government officers who worked in the power and energy sectors. The following maps (Figure 3:7) indicates the research areas and locations of places that the network took me to during the fieldwork.

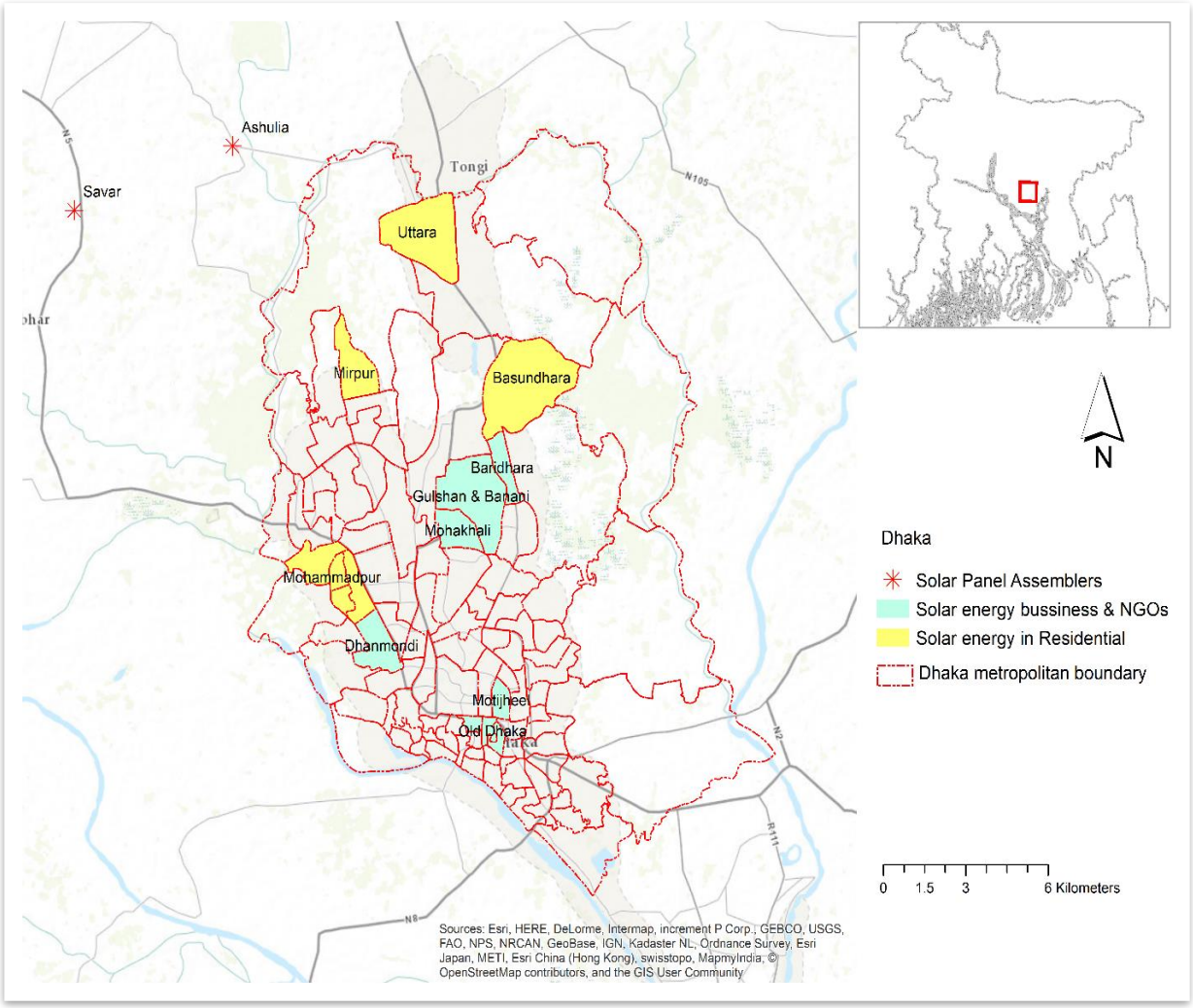


Figure 3:7 Map of urban solar energy entry points and solar energy market entry points. Source ESRI, modified by Pammi Nitin Sinha

Solar Energy Market Entry Point

The fourth and last entry point for this study was the solar energy market (Figure 3:7). It is difficult to pinpoint a single location as to where the solar energy market 'exists', and so I understand this entry point to be a market comprising a collection of activities that involve buying and selling solar energy products for transition to a low-carbon transition. For this research, I frame this as a relational space (Castán-Broto, 2017) which helped this study to investigate a wide range of actors, materials, and ideas which had been playing a vital role in the transition to this technology. The solar energy market entry point allowed me to engage with both multi-scalar local and global actors, and also a flow of discourse, ideas, power and resources. This entry point offered my research the possibility of gathering information about the impact of solar energy transition in the electricity sector, together with the intended and unintended consequences of different solar energy initiatives and energy policies on the local market. I realised that the open-ended mode of enquiry of this vast, complex relational space not only included local actors but also a wide range of international actors which was beyond the capacity of this PhD research.

3.3.2 Fieldwork Routes

The fieldwork began formally with a meeting on 15 October 2012 with Dr Rafiqur Rahman, who worked as a doctor in Karimpur hospital on Narsingdi where a solar home system was installed in 1997. Although Dr Rahman did not live on Narsingdi during that time, he had kindly offered to support me when introducing myself to the villagers. Support from Dr Rahman was useful, as through him, some of the former solar energy users agreed to meet and share their experiences of using solar energy between 1997 & 1998. After initial guidance from Dr Rahman, I used the traditional methods of snowballing to extend my networks of contacts, as it is a very effective way to increase the number of potential interviewees (Weiss, 1994; Thomson, 1997). I had wanted to stay in the villages to gather detailed information about the early stage of solar energy, yet being unable to secure accommodation on Narsingdi or nearby areas, I had to commute from Dhaka everyday day which took more than three hours to reach the research location. The commute between Narsingdi and Dhaka hindered the progress of the fieldwork. Furthermore, it was suggested by the locals that I should leave the island before sunset, as returning after dark might not be safe for a lone female researcher.

Although I did not achieve a great deal in terms of getting information about the Nasingdi solar energy project on Narsingdi, support from Dr Rahman as a gatekeeper encouraged me to secure help from locals as other gatekeepers. The importance of gatekeepers has been

repeatedly emphasised in the literature (Feldman et al., 2003). Scholars remind their fellow researchers to choose gatekeepers carefully, as the presentation of oneself as researcher can be confused or ruin the research process (Crang & Cook 2007). Thus, I chose my gatekeepers carefully throughout the fieldwork, so as not to risk ruining the research process. Being born and raised in Chittagong, the closest biggest city to Sandwip Island, I knew several people whose relatives are from Sandwip island. Using my personal connections, I arranged three meetings with people from Sandwip who may live in Chittagong but regularly visit families on Sandwip.

The meetings with gatekeepers were useful in gaining practical knowledge about travelling, arranging accommodation and contacting local people who could play a vital role as further gatekeepers. Here I must admit that being unable to arrange accommodation on Narsingdi made me nervous about the possibility of failing to secure accommodation on Sandwip. I considered Sandwip as a crucial entry point of this research, since it comprised the substantial focus of this thesis. Besides, location-wise, it would have been impossible to travel to every day. Therefore, this time I tried a number of sources to secure accommodation during my fieldwork on Sandwip.

The first accommodation that I managed to secure through my social network was in family accommodation in a village called Sharikait, the southern part of Sandwip. I lived with a family where ten members of three generations lived together. Two sons of that family lived in Saudi Arabia. The advantage of staying with a local family was that it gave me a chance to observe everyday activities in off-grid life. My stay with the host families while I was waiting for the guest house to have space, gave me the most insightful data for this research. The first thing that I learned by staying in a solar energy household was that to fulfil all the needs of daily life, a household needs to keep several kinds of energy. The household that I stayed with met their daily needs through a medium-sized solar home system, kerosene lamp, a rechargeable torch light and wood for cooking. The second thing that I observed from living with the host family was their need to all have similar kinds of mobile phone as the household had only one fixed wire to charge similar types of cell phone. Hence, I had to buy a cell phone of a similar model so that I could use the charger in the house and organise the rest of the fieldwork.

After staying with the family for two weeks, I moved to different accommodation and stayed with another family for a week. The second accommodation that I stayed in was with a mother and a daughter. Like the first accommodation, the man of this family lived abroad. Staying with different families in those three weeks, I gathered an in-depth understanding of everyday ‘tricks’ for using solar energy; everyday interaction between family members; relationships between technology and people and social relationships between neighbours. I would not

have been able to gather all of this insightful information if I was only conducting interview to investigate off-grid lives. My interaction with the different members of the host families proved to be useful when I started doing my data analysis; informal conversations with host families over shared meals helped to shape my understanding of people's lives in off-grid areas.

During my stay, the host families introduced me to their neighbours, and I developed a good relationship with villagers and started recruiting the participants by snowballing. At the same time, I started paying visits to NGOs and solar energy retailers in bazaars, and beginning to build a rapport with them. Afterwards, I moved to a government-owned guest house and stayed there until the end of my fieldwork.

3.3.3 Fieldwork in the national crisis

As I prepared for fieldwork, I learnt that the political situation in Bangladesh was increasingly volatile because of tensions emerging prior to a government election. Bangladesh has a long history of pre-election violence. However, this time, the pre-election violence began two years (in June 2011) before the election, as a consequence of a disagreement between political parties about going for election under a neutral government. Moreover, the situation deteriorated further when an ongoing international war tribunal sentenced a war criminal of the independence war of Bangladesh[10]. When I was in the field, I had to report to Durham University, and assure them that I was taking measures to stay safe. It was difficult to move from one place to another, as the whole country was in deadlock because of continuous strikes and extreme – deadly - violence. My initial fieldwork plan was to conduct my fieldwork from September 2012 to July 2013. I changed my fieldwork plan and went back to Durham, as it was neither safe nor practical for me to remain. I waited five months, hoping that the situation would change. However, the situation did not improve, thus I decided to go back to Bangladesh and continue the fieldwork as best as I could in the circumstances.

I began the second phase of my fieldwork on the 27th of September 2013. This time my fieldwork was based in Dhaka to cover two entry points: the urban rooftop policy and the solar energy market. I contacted the participants and arranged interviews according to their preferences. To minimise the movement risk, I stayed in three different locations and only contacted those participants who worked and lived in nearby areas. It was very difficult to

[10] The political violence situation escalated because of the Bangladesh War Crime Tribunal verdict. On the 5th February 2013, the International Crime Tribunal (ICT) sentenced the Islamic party-political leader Abudul Quader Mollah to life imprisonment after he was convicted on five of six counts of war crimes. A protest began in Shahbag, near Dhaka University, with Bangladesh following demands for capital punishment for Abdul Quader Mollah.

conduct fieldwork and collect data during the ongoing crisis. My fieldwork suffered extensively due to political unrest and the national crisis- this was something that I could not control. Time magazine reported that due to political violence, around 322 people were killed in political clashes that year, and it is believed that the death toll was one of the highest outside a conflict zone (The Times, 06-11-2013). Going out and moving from one place to another place was terrifying because of the extreme violence. Thus, the fieldwork became restricted and took more time that I anticipated.

3.4 Methods of data collection

According to Falzon (2009:1) "ethnography is an eclectic methodological choice which privileges an engaged, contextually rich and nuanced type of qualitative social research". Further, a multi-sited ethnographic approach is an open-ended approach to research that allows for ethnographic research to be complemented successfully with a whole suite of methods including several field sites. The advantage of adopting an ethnographic approach is that it is fluid and flexible, meaning a researcher can constantly adjust and reflect on the data being gathered. Instead of starting with a set hypothesis to test, ethnographic research often lays out a theoretical problem or question that guides the evolving design and process of the research (Smith and High, 2017). Recognising the significance of everyday and micro-politics in energy transition, increasingly researchers are using an ethnographic approach to research energy in order to understand detailed information about energy transition[11]. The following section explains the methods that are used to collect data during fieldwork.

3.5 Participant observation

Participant observation is the key ethnographic method that leads an ethnographer to a deeper understanding of the everyday lived experience (Crang & Cook, 2007). Participant observation and interactions enable the ethnographer to understand how a group develops a skein of relations and cultural constructions that tie it together (Herbert 2000). To understand the process of energy transition and everyday life of solar energy users, participant observation was the key method in this research. Studying energy and how people interact with energy and technology could not be effectively explored without participant observation. It is a method which helps a researcher to identify the gap between what people are saying and their

[11] In 2017 a special issue on energy transition was published in the journal Energy Research and Social Science. Furthermore, in the Annual Conference of The American Association of Geographers (AAG), a session entitled Energy Ethnographies: Foregrounding the social, cultural, and political aspects of 'energy access' and 'energy transitions' in the global south was organised, which also confirms the growing interests of ethnography in energy research.

in/actions because studying energy is predominantly about how people interact with energy and technology and what the practices based on energy sources and availability in people's day-to-day lives are.

Participant observation was undertaken in multiple spaces within the different energy users' houses, living with solar energy users' families and sitting with women for evening chats, and spending time in the local hospital or other establishments were running from solar electricity. Attending solar energy users' training sessions, following a solar engineer in his daily duties, and being part of installation events, were also useful to get an overall sense of the topic. Participant observation from these locations not only provided the understanding of daily activities but was also helpful in exploring people's interaction with energy, their needs and usage. I lived in two households on Sandwip which gave me exposure to, and an in-depth understanding of, the rhythm of life with different forms of energy. Participant observation therefore enabled me to access intimate aspects of energy use, such as the decision-making process of when to allow children to watch a full film and when to ask them to stop; the allocation of energy use between family members after daylight; the priority of work within the family, and the gender dimension of energy use.

Attending events

Adopting an ethnographic approach to my research, allowed me to bring together multiple methods to gather data and participants. I attended several events (Figure 3:8) that I was previously not aware of and did not have any plan of attending when I was making the network map. For example, I was not aware of customer training events until I went to Sandwip. I attended three customer training sessions organised by different NGOs on Sandwip. Attending consumer training offered three advantages: first, the events helped me to observe what kind of knowledge and information was passed on to the customer; second, it gave me a chance to see the relationship between customers and NGOs; and third, I recruited research participants from those events.

Figure 3:8 Customer training event in South Sandwip. Source: Author

I spent hours on Sandwip in different NGOs' offices to observe the interaction between the customers and NGO employees. I followed one NGO employee who works as a solar engineer on Sandwip. I observed his daily activities closely and observed the solar home system installation process. Following the solar engineer not only offered knowledge about NGO activities, but also gave me an insight of the relationship between the clients and sellers (Figure 3:8).

Figure 3:9 Following solar home system installations process. Source: Author

I also attended broader events, including a renewable energy fair and clean cookstove inauguration programme. These events helped to capture the momentum of solar energy transition, and to recruit participants for the research.

Figure 3:10 Launching programme of Clean Cookstove. Source: Author

During the fieldwork I kept note of the observation and maintained a fieldnotes diary. Later my research diary helped to refresh my mind and gain a deeper understanding of how solar energy users live and engage with solar energy in their everyday routine (Crang and Cook, 2007). The entries of research diary also captured my own experiences as a solar energy users. For example, the text box 2 where I wrote my first experience of living in an off-grid life. This kinds of fieldnotes refreshed mind and helped to present the field data in an effective way.

Text Box 2

Excerpt from field diary 03/12/12

Living with little: when a solar energy researcher becomes a solar energy user

Situation:

In this accommodation where I am staying, there is a mixed power supply. It has electricity from a diesel generator and solar home system. With the electricity from the generator I can run lights, fans and a plug point to charge an electronic device; but with solar energy, I can only run lights. Here it is important to note that electricity from the generator doesn't run 24 hours, it is limited for night time only. Usually, just before the evening prayer which is called Mugreeb prayer, the generator turns on and supplies power until 11 pm. During this time, I can have a big bright tube light to read or work, a fan to enjoy, and a charging point to charge my essential electronic devices: laptop, digital camera, dictaphone and of course a cell phone. After 11 pm when the generator goes off, I can then have only a single light which is not as bright as the generator powered tube light. That's all. This single light is powered by a solar home system and it runs until the back-up of the battery runs out. After 11 pm, I can't run the fan and can't charge electronic devices using solar electricity because the house doesn't have any arrangement or system to charge any electronic devices. Therefore, now I have to see how I am going to cope with this situation.

Coping Strategies:

The first thing that I did to deal with the situation, I bought an extension which has multiple sockets to charge all of my electronic devices together at the same time. Considering the limited electricity supply time, I had to plan and behave rationally in using my electronic devices. For instance, I would not use my laptop for playing music, internet browsing, reading e-books or journal; I would only use the laptop for writing and checking important emails. I wrote most of the notes and emails on paper. Another extremely important mechanism is I need to get back to the accommodation as quickly as possible after dark or before the electricity supply turns on, so that I don't miss a moment of that limited power supply span to charge up all of my electronic essentials. I always had to make sure that I am well equipped until next day of power supply starts.

Self-realisation:

In the first day of the accommodation, when I bought that extension to charge all of the electronic devices with me, before putting on, I flipped over the devices and wanted to learn how much electricity will these devices consume, is it too much to consume, is it going to blow up, etc. Honestly speaking, I never thought of checking how much electricity my laptop and cell phone use to charge before I came to Sandwip

3.5.1 Interviews

In addition to participant observation, interviews are a key tool for doing ethnographic research (Crang & Cook 2007: 60). As Atkinson and Silverman (1997) argue, the face-to-face interview enables an insight into subjectivity, voice and experience. Two kinds of interviews were carried out throughout the fieldwork: un-structured and semi-structured interviews. In rural households, most of the data was collected from informal chats (unstructured interviews), whereas semi-structured interviews were used with business organisations and urban households. Although interviews with solar business people and other officials were arranged formally, the semi-structured nature of the interviews allowed me to alter my sequence of questioning and probing for more information (Gilbert, 2002). The advantage of this method is that 'it allows interviewees to construct their own accounts of their experiences by describing and explaining their lives in their own words' (Flowerdew and Martin, 1997: 111).

Table 3:2 List of interviews conducted during the fieldwork

Entry point	Interviews
Narsingdi solar energy project *Karimpur and Nazarpur* Total Interviews- 7	5 Former users of solar energy 1 Researcher who worked has a consultant 1 Rural Electrification Board (REB) high official
Sandwip Island Total Interviews- 40	13 Solar home system users 10 Solar mini-grid users 8 Partner Organisations (PO) of IDCOL SHS programme 4 Retail Solar Home system sellers 1 Mini grid owner 1 Mini grid landowner 3 Non-Solar users
Urban rooftop solar energy policy Total Interviews- 21	13 Solar energy users 3 Real estate company 5 Urban solar energy providers
Solar energy market Total Interviews- 28	3 Solar technology equipment suppliers 4 Solar panel assemblers 2 Solar Battery producers 3 Solar technology equipment producers
	1 World Bank official 2 GIZ official (extemporaneously formed 1 focus group) 1 KfW official
	3 Infrastructural Development Company Limited (IDCOL) officials 3 Academic/ solar energy experts- work as technical consultants

Interview respondents were selected based on the various entry points. In Sandwip, solar energy respondents were selected based on the different technologies that they use, i.e. solar home systems and the solar mini grid. In addition, using the network map, I added different actors that were involved in the solar energy transition. In the beginning, I struggled to conduct interviews and obtain information from female solar energy users on Sandwip. On several occasions, women were shy to talk with me at first; this was perhaps due to societal conditioning (Sultana, 2007), and relatedly that rural women are not used to talking to a stranger and expressing their opinion. I therefore had to work through such relations and build rapport in order to proceed. I discussed my struggle with a former colleague who carried out fieldwork in rural areas and they recommended that I organise interviews in pairs: “sometimes women are more comfortable when they have company”. This technique proved useful on

several occasions. Along with this technique, I paid several informal visits beforehand to the women to build relationships and to gain their trust.

The majority of the interviews in solar energy market entry point were not recorded, as respondents expressed their discomfort with me recording their voices while they are criticising the authority or the system. Some of the respondents told me that I could record if I wanted to, but their answer would not be spontaneous; there would be some issues they would want to share with me, would not do so if they are recorded. Continuing the conversation while I was writing notes during the interview was difficult. However, I tried to take note and tried to capture their quotes the way they delivered. Sometimes right after the interviews I recorded some of conversation in my own voice so that I do clearly remember how they responded to some of the questions. To capture wider information on a respondent's expression, I kept detailed notes during the interview. This helped me to guide what was being said and the likely meaning and intent of each statement (Crang & Cook, 2007: 137).

3.6 Document analysis

Documents can provide a particular form of knowledge through the relations of power between social, political and economic actors that can be identified. Document analysis involves analysis of content from written documents either to understand their substantive content or to illuminate deeper meanings which may be revealed by their style and coverage (Freeman and Maybin, 2011). In my research, document analysis played a vital role in collating office data. It involved public documents like media reports, government papers, policy documents or publicity materials, business brochures, procedural documents, etc. In my research I treated documents as sources for identifying the position being taken by a government or other public authorities on a particular policy topic (*ibid*: 157). It worked as a powerful tool that helped me to gain an insight of official intentions, objectives, commitments, proposals, thinking, ideology and responses to external events. Due to time constraints and the political chaos, I did not manage to arrange some of the interviews with high officials that I had identified as key actors who play a vital role in the solar energy transition. Thus, government policy documents helped me to fill that gap and re-check the validity of information that I gathered. Furthermore, the business brochures that were collected during my fieldwork revealed additional information, for instance, on business strategies, technologies, and different market offers that helped me understand how the market advanced the development of solar technology. Following figure (3:11) displays some of the brochures that I collected during the fieldwork.

Figure 3:11 Collected business brochures from Renewable Energy Fair. Source: Author

3.6.1 Visual methods

The importance of visual representation has gained increasing attention within the social sciences. The benefits of visual representation as a research method and as a tool to represent the research is that visual representation can go beyond words, and it has a long lasting effect on people (Harper, 2002). One advantage of visual methods is that not all participants were able to explain themselves verbally. Sometimes not all experiences are best expressed through words, and sometimes visual expression can convey the message without having a narration from the participants. This research used both still images and video for data collection and presented the work visually to the wider audience.

Photography

Photographs, film and video are increasingly used as genuine forms and sources of data (Becker, 1986; Denzin, 1994; Harper, 2004) and as second-hand observation (Flick, 2006). According to Hawkins (2015: 251), photographs are “more than visual field-notes”. One may argue that “arranging a subject in a photo results in it losing moments of expression” (ibid. pp 237), but for this research, photography complemented the ethnographic approach and provided a tool for data gathering with an explicit focus on the material and technological dimensions of my research.

In this research, photography was used as a tool for two reasons. First, it was used as a data register (of technologies, sites, and moments) to complement observation; and second, it was used to support analysis by providing a visual record that could be accessed after the fieldwork phase and illustrate the ethnographic descriptions and insights. The photographs often revealed information that may have been missed during fieldwork or, on many occasions, photography played a role as a visual reminder. While the original intention was to make use of photography in a more explicit way as a strategy for analysis, its final use was limited primarily to data recording. In short, photographs not only made my argument stronger but also refreshed my memory of the field.

Film: Off the Grid

Besides photography, this research also used film as a research method. "According to Crawford et al. (1992) the visual particularly film as research method, recoding, probing, and sometimes being as agent or actor in an event allows us, through the addition of subtitles, to form a better understanding of the nature of the inquiry and therefore of the quality of the material obtained (Crawford et al. 1992, p.6 cited in Kharel, 2015). Therefore, to make the field enquires more accessible and insightful, a film was produced in collaboration with a film maker[12]. The research findings are presented by a storytelling method through the film. Presenting the daily routine of solar energy users on Sandwip Island, showing three lives – those of a solar engineer, a teenage girl and a mother/wife - we produced a film to use as a powerful visual medium to communicate with a wider audience than solely an academic one. The film was screened in several academic conferences, workshop as well as in many film festivals.

3.7 Data Interpretation & Emerging Themes

Data interpretation and analysis began with an attempt to order the data gathered through research diary notes, interviews and research questions in the field to develop a rough idea of the themes coming out from the field data. I followed an open coding procedure to extract categories found in the materials that helped to avoid biases to certain categories; and, as Crang & Cook (1997) say, to 'avoid imposing some outside set of categories'. Then, I arranged the categories and identified three broad themes: everyday life of solar users, market expansion and development. Each theme forms a chapter in the rest of the thesis and is linked with the wider theoretical considerations. In this procedure, my theoretical notes and analytical memos greatly supported the process of data analysis. Theoretical notes helped me make

[12] Trailer of Off the Grid: https://vimeo.com/121374407

meaning of my data, by asking myself questions such as: ‘What are your initial explanations?’, and ‘What is your data telling you?’ On the other hand, analytic memos helped me to review my theoretical notes and begin to see patterns or recurrent themes in the data. This helped me to make a link to analyses in the energy transition literature.

Reflexivity has been increasingly recognized as a crucial strategy in the process of generating knowledge by means of qualitative research (Hammersley and Atkinson, 2002). Methodological reflexivity is a systematic means to a deeper and better understanding of the complex “knowledge-making enterprise, including a consideration of the subjective, institutional, social, and political processes whereby research is conducted, and knowledge is produced” (Alvesson, 2007). “Questions about reflexivity are therefore part of a broader debate about ontological, epistemological and axiological components of the self, intersubjectivity and the colonization of knowledge” (Berger, 2013: 2). In my research, reflexivity was ensured by keeping a research diary: a place for recording reflections where I kept notes of all sorts, i.e. observational notes, methodological notes, theoretical notes and an analytical memo (Blaxter, et al., 2001). The observational notes were recorded on events such as interviews, chance encounters, and observations conducted throughout the fieldwork. My notes also contained some interpretation, which was useful later on during the data analysis process. Further, methodological notes were used to reflect upon the methodological aspects of research: including how the interview went; what my role in it was; which methods ‘failed’; and which methods worked well. These notes helped me to write the methodological aspect of this research, especially this chapter.

3.8 Challenges, limitations and lessons learnt

3.8.1 Consent form

Informed consent is a voluntary agreement to participate in research. Informed consent has been an integral part of any research that has been embraced by various regulatory bodies research council, universities. Obtaining consent involves informing the subject about their rights, the purpose of the study, the procedures undertaken, and the potential risks and benefits of participation. As this research was conducted following the principles of research ethics outlined by the Geography Department at Durham University, I was obliged to obtain written consent from the participants. I prepared both English and Bengali consent forms for the participants so that I could meet the respondents’ comforts and needs. As one of the field sites was in a rural area, I knew some respondents would not be literate and that I would not be able to get signed consent in these cases.

However, gaining written consent did not succeed much in either rural or urban areas. People generally think signing a form is a significantly important issue which makes them suspicious about the intention of the researcher (Zaman and Nahar, 2011). Therefore, verbal consent was gained from these respondents. I realised that there were two reasons why people were not comfortable signing the consent form. First, in Bangladesh informed consent is not strictly followed by local researchers, so as soon as I asked them to sign, they started questioning and comparing my methods with those used in other research studies. Second, although I informed them that their views would be presented anonymously, they were still unsure of signing consent, a concept which was completely unknown to them. One respondent even asked me: "is it not enough as consent that I agreed to meet and invited you to my office to take part of your research?" Furthermore, I had to interview many solar business entrepreneurs who may not have been following the business code and conduct, and selling sub-standard products. Thus, as soon as I asked them to sign a paper, they started questioning my research intentions and on some occasions, they decided not to take part in this research.

Haggerty notes that the standard expectation of securing formal consent is problematic, and continues to say that "an unfortunate consequence of these developments will likely be that researchers will choose to employ certain types of unproblematic and often predictable research methodologies rather than deal with uncertainty and delays associated with qualitative, ethnographic, or critical scholarship which does not fit easily into existing research ethics template, the more we risk homogenising inquiry and narrowing vision, as scholars start to follow what they perceive to be the path of least institutional resistance" (2004: 412). Thus, I gathered verbal consent from the respondents and presented the name of the respondent anonymously in such a way that cannot be identified. It is important to highlight that all the name appeared in this thesis are pseudonyms.

3.8.2 Ethical concerns

Ethical considerations in research are critical. I positioned myself to perform this research in accordance with the ethical guidelines set by the Geography Department of Durham University. Several ethical concerns were encounter by this research and I tried my best to minimise those issues using University's ethical guideline as well as moral commitment. As Sultana (2007) argues in order to minimise the potential harm, sometimes ethical considerations can be shifted away from the strict codes of institutional paperwork towards moral and mutual relations with a commitment to conducting ethical and respectful research.

The first ethical issue that I encountered is managing the expectations of the respondents. In Sandwip I realised that some of the respondents assumed that my research could bring electricity to the island. One elderly respondent told me once “you should write everything that I told you, the government need to listen what people in Sandwip want, people in Sandwip want electricity, not Solar”. I was truthful and explained him that it would be beyond the capacity of a PhD thesis to hold all the information that I gathered during the fieldwork. I made the respondents aware that based on the information that they shared with me I would produce a thesis and publish papers in academic journals. I also told the respondents very clearly as a PhD researcher at this early stage of my career, I did not have any direct influence on the energy policy of the country.

The second ethical concern is related to anonymisation of the respondents’ identity. I promised that I would anonymise the name of the respondents in such a way that their identity cannot be identified. However, while I was writing this thesis, I realised that there were originations that are easily identifiable even though I anonymised the name because during the time I conducted fieldwork only one mini-grid project was in operation in not only in Sandwip but also in entire Bangladesh. To overcome this complication, I tried not to use the position of those respondents who are easily identifiable. For example, when I used a quotation from a solar businessman or NGO workers, I anonymised both the name the person and the organisation he worked. Furthermore, referring to high official of the state, or donor agencies, I frame their position more broadly, for example as “an expert who works in international donor organisation” or “a high official works in energy sector”. Taking this extra measure, I tried to minimise the risk of them being identifiable.

3.8.3 Positional space

During the research, I encountered numerous empirical difficulties including business politics, organisation tension, and respondent selection, over-attention, and gatekeeping complications. In this section, I will be exploring these challenges and how I faced them. The most prominent challenge that I experienced was the complication of ‘positional space’ (Mullings, 1999) that usually comes from the internal politics of research sites. As the fieldwork was involved with solar energy business organisations, solar energy users, policy makers and different national and transnational agencies, the internal politics between different actors sometimes created complications with regards to collecting information about the problems and difficulties encountered in solar energy politics. To survive the business competition, many solar energy providers did not admit any problems with their services or products. There was a tendency among many solar energy providers, NGOs and even some of the officials, to provide the ‘official version’ that could be found on their organisation’s website.

Furthermore, due to illicit practices, some of the solar energy providers, retailers and urban solar energy users did not want to take part in the research as they suspected I would leak the information to the authorities. When I explained the intention of the research, one solar home system seller asked me if I were disguising myself, using the excuse of researching to get actual information about his organisation and inform his competitors. On Sandwip Island it took a while to gain the trust of potential respondents that I was approaching: some of them then opened up because they were monitoring my activities. Another problem was that many of the respondents were not familiar with research practices, especially ethnographic research where a researcher spends a long time in the field. One NGO worker asked me: “How come you are spending such a long time doing this research? We have dealt with a number of researchers who came and spent probably 2/3 days and went back to the city”. Thus, unfamiliarly with research processes created doubt in some of the respondents.

3.8.4 Researching as a lone female researcher

Accommodation

As previously mentioned, finding accommodation for a lone female researcher was challenging throughout the fieldwork. As a Bangladeshi, I already knew that finding accommodation in rural field sites would likely be challenging. On Narsingdi no hotels were ready to accept a female boarder, due to security reasons. However, I did not expect to experience difficulties when I was looking for accommodation in Dhaka as well. I realised that I have very limited knowledge about my own country, and sometimes I felt like an outsider who needed to inform herself on the cultural norms and practices of Bangladesh. When I was making initial contact for accommodation in Dhaka, I made some enquiries with a landlady who is a doctor by profession. She agreed to let her apartment to me if my parents accompanied me. I convinced my parents to come and visit me occasionally to ease my situation. However, she still asked me many other questions and she cautioned me: “From the 15 November, the whole building will be occupied by men and their staff. You will be the only one lady living in that apartment. Have you ever lived in Dhaka alone? I don’t think this is a good idea! THIS IS NOT UK!”

After facing difficulties in both Dhaka and Narsingdi, I explored every single source to secure accommodation on Sandwip. I simultaneously tried to get accommodation in hotels, a government guest house and personal residences. Like in Narsingdi, hotels on Sandwip also refused to take female boarders. Thus, the first month in Sandwip I stayed with local families using my personal network while I was waiting to hear from the government guest house. After a month, I got permission to stay in the government accommodation on one condition: when

the accommodation was full, and the guest house would require a room for the government official, I would need to move out.

Cultural appropriateness

Cultural appropriateness is important for any research especially if one is going to study a closed community in a rural place. A number of research methods often suggest that researchers keep in mind cultural appropriateness. For instance, Hapke and Ayyankeril (2001) mention appropriate clothes, appropriate cultural behaviours choosing research assistants, etc. Having trained in Anthropology and Human Geography, and being Bangladeshi, I took all the precautions necessary to blend in and get accepted easily. However, I was still surprised when I realised that being single at the age of 30 is not culturally appropriate, especially in rural areas. While I was arranging my first accommodation on Sandwip with a host family, one of my gatekeepers introduced me as a married person, so that I could gain respect in the community. According to Ka un (the gatekeeper) "this is not common in rural areas where no women your age are single nor travelling unchaperoned: this may hamper your research process and villagers might not consider you as a "*Bhodromohila"* ("respectable" woman). This situation put me in a dilemma as to whether I should be truthful and inform the participants that I am a single woman. It was difficult for me to accept the gatekeeper's judgement, on the one hand because it was a lie which I did not want to tell; and on the other, because my personal ideology was at stake: I was endorsing the idea that women in their 30s cannot be single or travel alone - a man should always accompany them. Indeed, Katz (1994) argues that the politics in the field are intensely personal. However, after getting a sense that some of the male respondents were too interested in my personal life (Nagar, 1997) and after experiencing two unpleasant incidents where local men attempted to step into my private space (Rush, 2012), I decided to put on a ring that looked like a wedding ring and a golden coloured bangle (another Bangladeshi symbol of marriage) to avoid unnecessary attention from the male respondents.

Power relations

Many have written that the power relationship between the researcher and the researched is not neutral (Bondi, 2003). A number of scholars have argued that the researcher needs to be careful in ensuring a non-hierarchical position with the researched. However, Sultana (2007, page) argues that "power relations can work both ways, especially if one is a young female researcher in an overtly patriarchal field context". In fact, although the researcher holds most of the power since she decides when and where to go when to leave, representing the participants and their lives, I agree with Sultana (2007) that on many occasions reverse power relations appeared, including in the many refusals to participate in interviews, not allowing

time for the interview, and behaving in a condescending attitude towards me and my work. People not only positioned me with ties to my educational institution in the West but also to my broader privileged position. On one occasion, I had to submit to a writing test for an old respondent who is a school teacher: s/he wanted to see whether I was literate, and knew the correct way to write letters and numbers in Bangla and English. As a Bangladeshi I was certainly aware of this patriarchal attitude toward women and age hierarchy, so in the interests of both getting the research done and not offending the people that I interviewed, I had to make the patriarchal bargain in negotiating and engaging politely with or and steer them back to my research questions (Sultana, 2007).

Doing research in a male dominated field

Power relations can be intense and add an extra challenge for female researchers when the field is a male dominant one (Soyer, 2013). Many times, I felt that my identity as a researcher was overshadowed by my female identity. People placed me in certain categories, 'othered' me and negotiated the relationship on a continual basis (Sultana, 2007). On many occasions, I had to deliberately affirm my knowledge about the field since solar energy is considered as a technical subject. Several times I had to assure others of my ability to do research alone without having a supporting team. I heard, a number of times: "You stayed on Sandwip for four months! Even men won't think of going there". Another respondent told me "You are a dangerous (brave) woman who dares to go to a place like Sandwip and stay there alone". My visit to Sunderban market (a retail market of electronic goods supply) was uncomfortable. When I went there to talk to the shopkeepers, many times I heard side comments, such as: "Madam why you are not coming to me? Don't you like me?"; and saw people taking photos of me without my permission. This kind of encounter made me feel uncomfortable and, in many occasions, I had to cut short the interviews and ignore those side comments.

Danger of gate keepers

Gatekeeping helped me immensely in gaining access and credibility within the community. However, there were some complications too. There are dangers of remaining largely dependent on the goodwill of the gatekeepers when a gatekeeper chooses respondents or attempts to control who you speak to (Sanghera & Thapar-Bjorket, 2008, Heath et al., 2004). My gatekeeper dependency was only for an introduction to the local people while the participant observations and interview procedures were generally done independently. Although initially I asked a couple of NGOs on Sandwip to introduce me to their clients, after conducting a couple of interviews I realised that the users did not understand the intention of my research. Rather than considering me as an independent researcher, they considered me as a representative of that NGO. Furthermore, because of the gatekeeper's presence, the

respondents were not open enough to disclose their actual opinion. On another occasion, some of the interviews were ruined by the gatekeeper as he/she would interrupt the conversations, so I revisited and arranged to have another interview later. The snowball method was useful to avoid these gatekeepers' complications.

Doing Research at 'Home'

My position of being a Bangladeshi brought enormous advantages such as access to language, culture, local norms and values, and so on. The issue of 'positionality' has always been crucial in any research. Positionality is not simply recognising the position of researcher and researched; it is about the position of every similarity and difference between the relations in research (Limb and Dwyer, 2001). Skelton (2001, p. 89) argues that "by positionality, I mean things like our 'race' and 'gender'… but also our class experiences, our levels of education, our sexuality, our age, and our ableness, whether we are, how our identities are formed and how we do our research". Doing research at 'home' also brings in different dynamics, regarding concerns of insider-outsider and politics of representation, across other axes of social differentiation beyond commonality in nationality or ethnicity.

Text Box 3

Excerpt from field diary 11/12/12

Being Bangladeshi, I don't have anything uncommon in my appearance, I do have the same dark black hair, skin colour, and I am even very cautious about my dress. I have chosen those clothes that are considered as 'appropriate' for rural areas. I didn't bring any outfits that I usually wear in Chittagong or Dhaka. I chose outfits which are long, loose and with long sleeves. However, whenever I go out of the guest house I can see curious eyes following me. Sometimes I wonder how they differentiate me from other women from the village. Having a similar appearance, I found it interesting that a number of visitors (neighbours) came to talk to me just because I came from the city. Many women have already invited me to pop in for a little chit-chat. Some of them told me I don't look like I live aboard: I look like one of them. This is a very good sign for my research (since it seems like many of the villagers have a negative perspective of city girls): it seems like I have already gained their trust as they are inviting me to their homes. This will allow me to get inside their house and closely see their lives and interactions with solar energy. I am thinking of selecting a few households from these connections and a few from solar energy companies for my work.

This is what scholars call ‘doing research at home’; but like Sultana (2007) I was often confused as to ‘what constitutes the ‘field’ versus ‘home’’, as returning to Bangladesh to do fieldwork was by no means returning home, because none of my field sites were the place that I am from. I was born and grew up in Chittagong, the second largest city of Bangladesh. Both field sites were different from the place I grew up in; however, I was familiar with both environments since my relatives live in both kinds of settings. Additionally, the many commonalities, including my nationality, gender, ethnicity, attire and ability to engage in regular conversation in the local dialect and live in the rural areas enabled me to bridge gaps and become more accepted over time.

My field experiences reminded me that despite similar historical and political processes; class privilege can create ‘otherness’ between researcher and participants (Lal, 1996). Because my Western education and four years of ‘living abroad’ status put me in a different position (Smith, 1999) that makes my native identity questionable, many times in the field I felt I was simultaneously an insider, outsider, both and neither (Gilbert 1994; Mullings 1999). On many occasions, I felt I struggled to separate professional and emotional considerations. For example, my feelings about local articulations of gender differences, their implications for women and women’s position in society troubled me throughout my fieldwork. The villages that I stayed in have a predominantly migrant based economy. 60% of the men move away from the island for work and leave their family behind. Men being away added extra restrictions for women: their feelings of loneliness, separation, uncertain futures, and fear of darkness distressed me. I realised that my personal visits to villages to visit relatives and visiting villages for doing research had brought completely different experiences. The research experiences challenged my comfortable position as an insider. I had to unlearn my own privilege (Spivak, 1993) and relearn many things during the fieldwork.

3.9 Conclusion

This chapter has explained the methodological approaches and tools used during the research. It has also reflected on some crucial issues like access, trust, positionality and ethics. Considering the nature of this research, this study chose a multi-sited ethnographic approach as an open-ended mode of enquiry. This research used participant observations, interviews, documents analysis and visual methods. Using these tools, this open-ended enquiry worked like ‘pearl fishing: one dives in not knowing quite what one will come up with’ (Arendth, citied in Dowler, 2001: 157).

Looking back at the methodological strategies adopted during the fieldwork, the mix of methods deployed inspired by a fluid and flexible approach helped this research to capture an

in-depth understanding of this messy and complex on-going energy transition in Bangladesh. While this adoptive method enhanced the fieldwork process, it was also difficult to determine a cut-off time or geographical location, as it involved multi-scalar national and international actors. Another limitation is that the research could have been benefited if season variation in solar power use could have investigated, as several interviews revealed that the pratice and expereinces of using solar techngloy varies by season. Due to time constraints, this was not possible. Furthermore, the research only explored the impact of solar energy transition in *domestic* usage, and did not include other projects, such as solar irrigation and the solar nano grid. Future research on non-domestic usage of solar energy technology is suggested in the thesis' conclusion (chapter nine). The next chapter turns to outline contextual information concerning the emergence of solar energy in Bangladesh.

Chapter Four: Understanding the Energy Transition in Bangladesh

Figure 4:1 A solar panel is on the way to illuminate the darken in an off-grid household

4.1 Introduction

This chapter provides contextual information about the emergence and diffusion of solar energy (photovoltaics) in Bangladesh and how this technology has come to be considered an important driver for the country's development. Energy access is increasingly seen as a vital catalyst to development, enabling education, health and sustainable agriculture, and creating jobs. The Millennium Development Goals (MDGs) were criticised for not recognising energy access as an agenda, but the post 2015 Sustainable Development Goals (SDG#7) have included energy as one of the key factors for sustainable development and poverty eradication. Moreover, the United Nations has declared 2014-2024 as the Decade for Sustainable Energy for All (SE4ALL), further underscoring the importance of energy issues in the post-2015 development agenda. This SE4ALL initiative aims to ensure universal access to modern energy services, improve efficiency and increase use of renewable sources. It is claimed that access to modern forms of energy is essential for provision of clean water, sanitation and healthcare, and provides benefits to development through reliable and efficient lighting, heating, cooking, mechanical power, and transport and telecommunication services.[13] Accordingly, access to electricity is seen as a central factor for a country's development. The government of Bangladesh has consequently taken several initial to be recognised as developing country from least developing country and improving energy situation is one of them.

To set the context for the rest of the thesis, in this chapter I outline the current state of the energy sector in Bangladesh and identify significant recent changes to electricity generation and supply (Section 4.1). I then move to explain different initiatives that the government has taken to solve the power crisis, as a part of the Power System Master Plan (PSMP) (Section 4.2). I then discuss the emergence of Solar Energy in off-grid areas in Section 4.3. Finally, I explain how and why solar technology was introduced as an alternative source of electricity that is able to bring rural development and help solve the urban electricity problem (Section 4.4).

[13] https://www.seforall.org

4.2 Reforming the Power Sector in Bangladesh: energy for development and the transition from state to market

For the past three decades, many developed and developing countries have embarked on power sector reform. These reforms have taken place within the backdrop of a wider paradigm shift from state ownership and centralized organization of infrastructure industries to private ownership, public regulation, and market competition (OECD, 2000 cited in Jamasb, 2006). Bangladesh has been struggling to overcome an inadequate and unreliable power supply since independence (Mujeri, et al. 2014) and economic reforms to the sector have taken place against the background of this long-standing power crisis.

Table 4:1 Electricity sector at a glance[14]

Installed Generation capacity including Captive Power (as on December 2017)	16,046 MW[15] 13,846+2,200 MW
Highest Generation	9,479 MW (07 June 2017)
Total Consumers	25.4 Million
Transmission Line	10,436 Circuit km
Distribution Line	4,01,000 km
System Loss	13.10% (June 2016)
Distribution Loss	10.69% (June 2016)
Per Capita Generation	321 kWh
Access to Electricity	63% of the total population

In 1971 when West Pakistan handed over the Energy Sector Board to the newly-formed country of Bangladesh, the capacity of power development was only 1200 MW. In the past 47 years, the electricity sector in Bangladesh has come a long way, but still the per capita electricity consumption (321 kWH) is considered one of the lowest in the world (see table 4.1). Despite the highest priority being given to the power sector by the government of Bangladesh, the total electricity generation capacity stands at 15,755 MW and provides electricity to only

[14] This table is prepared by the author from multiple online sources (BPDB, Energy and Mineral websites, various presentation slides by energy sector government officials)
[15] http://www.bpdb.gov.bd/bpdb/ accessed on 10/03/2018

63% of the population (25.4 Million). It is also important to recognize that actual electricity generation is significantly less than the installed capacity (it currently stands at approximately two thirds of this, see Table 4:1). The peak of electricity generation (9,479 MW) was recorded on 07 June 2017, and is considered a milestone in the country's energy history. If we look into the history of electricity in Bangladesh, there has always been a gap between electricity generation and demand because of the rapid growth of the population and the country's electricity-intensive form of development.

It is important to note that ddemographic pressure is not the only reason for the power crisis in Bangladesh, however. Other factors include shortage in fuel supply for power generation, ageing power plants and equipment, lack of timely maintenance, and less production capacity (than the amount agreed) of 'quick rental' power plants[16] (Ahamad & Islam, 2011). In addition, it is often argued that the organizational inefficiency of the public sector, corruption and long-standing negligence, as well as large financial deficits of the state-owned energy utilities and political interference in organisational management are responsible for the poor performance of the state-owned utilities that created the electricity crisis (Ahmed, 2011). Analysts also point out that the energy sector has failed to attract adequate private investment due to poor pricing policies, a lack of appropriate organisational structure, inefficiency in the decision-making process, and political instability (Gutierrez, 1996; Zekeyo, 2001; Rudnick, 1996; World Bank, 2001).

Over time, a number of initiatives have been developed in attempts to overcome the power crisis. These include reforms to energy policy, the restructuring of the energy sector, and the diversification of energy sources. The international community has also been involved in this process. For example, the first reform in the history of Bangladesh electricity the distribution segment in 1977 (Gupta et al., 2012) involved The National Rural Electric Cooperative Association (NRECA), International Ltd., and Commonwealth Associates Inc. (now Gilbert Commonwealth) carrying out a comprehensive feasibility study on Rural Electrification in Bangladesh via a USAID-financed project. The study recommended an Area Coverage Rural Electrification programme based on the principles of a consumer's co-operative and initiated a new power authority for rural electrification called the Rural Electrification Board (REB). This was established in 1977 (Muhammad 2003). After 1977, the Bangladesh Power Development Board (BPDB) was made responsible for electricity distribution in urban areas, and rural areas were made the responsibility of the Rural Electrification Board (REB).

[16] Many of the quick rental power plants that are currently under operation are facing technical difficulties thus often they fail to produce their maximum capacity (Ahamad & Islam, 2011)

Bangladesh has been gradually opening up to the multiform flows of globalisation and neoliberalism since the early 1980s, and as a consequence, the power sector has been systematically reformed and privatised during this period (See Table 4:2). The stated purpose of this reform has been to ensure an efficient and more economically-sustainable system of electricity generation, transmission, and distribution. Perhaps most significantly, the country's power sector enacted a Private Sector Power Generation Policy in 1996, allowing Independent Power Producers (IPP) to enter the market and share the load of electricity generation. This policy broke the monopoly business of the state-owned BPDB in generation, and created a new era of competition between public and private power generation.

Table 4:2 Key Policies and legislation affecting Power sector

National Energy Policy, 1996
Private Sector Power Generation Policy of Bangladesh, 1996
Policy Guidelines for Small Power Plant (SPP) in Private Sector, 2000
The Bangladesh Energy Regulatory Commission Act, 2003
Policy Guidelines for Public Private Partnership
Policy Guidelines for Power Purchase from Captive Power Plant, 2007
Guidelines for Remote Area Power Supply System (RAPSS), 2008
Policy Guidelines for Enhancement of Private Participation in the Power Sector, 2008
Renewable Energy Policy of Bangladesh, 2008
The Bangladesh Private Sector Infrastructure Guide Lines
The Sustainable and Renewable Energy Development Authority Act, 2012
Energy Efficiency and Conservation Rules, 2015

Source: Ahamad and Tanin (2013)

As an example of this new era, Meghnaghat Power Plant (MPL) is considered the biggest and most successful of the Public-Private-Partnership[17] (PPP) power plants. It was established in 2002 under a 22-year build-operate-own (BOO) power purchase arrangement with the Bangladesh Power Development Board (BPDB). The project was funded by the Asian Development Bank (ADB), and was mediated by the Infrastructure Development Company Limited (IDCOL). IDCOL is a state agency formed in 1997 by the Government of Bangladesh (GOB), with assistance from the International Development Agency (IDA) (a member of the World Bank group). To encourage private participation in the development of inland infrastructure, the GOB set up IDCOL as a non-bank financial institution (NBFI) to promote economic development by boosting private sector investment in energy and infrastructure projects. The success of MPL initiated a "Public Private Sector Power Generation Policy" (PPGP), which accelerated participation of private companies in the power sector as Independent Power Producers (IPP). At the same time, the construction of public sector power plants was halted due to International Finance Institutions (IFIs) being reluctant to fund the public sector. It is thought that four public sector power generation projects - Barapukuria (coal-based), Shahjibazar, Baghabari, and Sylhet (all gas-based) - were postponed, and that a decision was made to carry them out via IPPs (Muhammad 2003, 2008, 2014). Gradually, some of the power sector has also been handed over to the Independent Power Producers (IPPs) or Multi-National Companies (MNCs), owned and controlled by Multi-National Corporations (MNCs)

[17] PPPs are contractual partnerships where responsibilities and risks are shared between the public and private sectors

The following section presents the structure and role of different entities of the power division in Bangladesh.

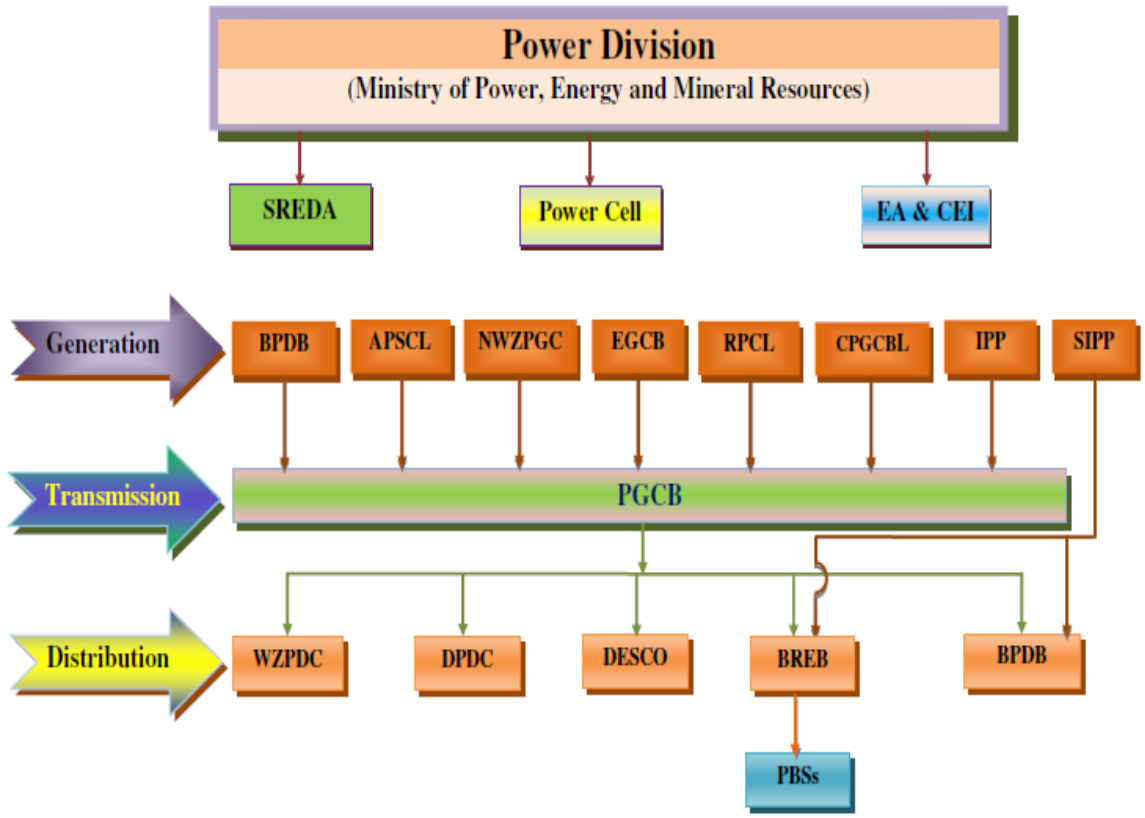


Figure 4:2 Power Division Structure. Downloaded from the Power Division website Source: http://www.powerdivision.gov.bd/

The Ministry of Power, Energy and Mineral Resources (MPEM) is responsible for all policies and matters relating to electricity generation, transmission and distribution from conventional and non-conventional energy sources. Through the combination of two broad divisions (the Power Division, and Energy and Mineral resources) the MPEM deals with the import, distribution, exploration, extraction, pricing and other policy-related details of primary fuels. To regulate all of the activities related to gas, electricity and petroleum products under MPEM , The Bangladesh Energy Regulatory Commission (BERC) was established in 2003. The BERC is the responsible agency for determining both the bulk and retail tariff rates of electricity, natural gas, petroleum products, coal and other mineral resources, with reference to the government's overall policies in the sector.

The Sustainable Renewable Development Authority (SREDA) is the latest addition to the power sector of Bangladesh. SREDA has been created as a nodal organization of the Government to promote and develop renewable energy, as well as energy efficiency activities, in both the public and private sectors. To promote and foster the renewable energy development in Bangladesh, a dedicated policy on Renewable Energy was also adopted in 2008. This policy envisages at least 10% of total power generation being developed from renewable energy sources by 2020. Finally, Power Cell was created in 1995 as a "Think Tank" to provide policy supports related to reform of the power industry and to promote private power development. Electric Advisor (EA) and Chief Electric Inspector (CEI) of the Electricity License Board ensures the safety of electricity generation, transmission and consumption by inspecting and providing licenses under terms originally established by the colonial-era Electricity Act of 1910.

The Power Sector in Bangladesh has been unbundled into generation, transmission and distribution companies. It has eight generation companies, one transmission company, and five distribution entities. The Bangladesh Power Development Board (BPDB) was created as a public sector organization in 1972 and is the oldest organization in the Bangladeshi power sector. BPDB is responsible for managing power generation, transmission systems, and distribution. Since the mid-1990s, the Government of Bangladesh has continued with the vertical unbundling of the sector through the creation of separate publicly-owned entities for generation, transmission and distribution, and the development of a Single Buyer market model (Ahmed, 2011).

Although the neoliberalisation of the power sector has opened this sector up to foreign and private involvement (particularly in electricity generation activities), it remains dominated by state-owned entities in generation, transmission (100%) and distribution. BPDB was assigned to manage power transmission systems, power generation and power distribution throughout Bangladesh until 1996, before the formation of the Power Grid Company of Bangladesh Ltd (PGCB). PGCB was formed under the power sector restructuring process with the objective of bringing a commercial attitude to grid management, including increasing efficiency, establishing accountability and adopting a dynamic approach to accomplishing its goals. PGCB is a public limited company, and is 76.25 % owned by BPDB; the remaining 23.75% is owned by the general public. PGCB is mainly concerned with the operation, maintenance and development of the power transmission system across Bangladesh. Expansion of the grid network, including installation of new transmission lines and grid substations are its prime responsibility. After its formation, the existing transmission system was gradually handed over

to PGCB from BPDB and DPDC. On the 31st December 2002 PGCB took over full responsibility for the total transmission system (Gupta et al, 2012).

Table 4:3 Current Entities of the Power Sector and their roles[18]

Power Division	Ministry of Power, Energy & Mineral Resources (MPE)
Technical arms	Power Cell EA & CEI SREDA
Regulator	Bangladesh Energy Regulatory Commission (BERC)
Generation	Bangladesh Power Development Board (BPDB) Ashuganj Power Station Company Ltd. (APSCL) Electricity Generation Company of Bangladesh (EGCB) Independent Power Producers (IPPs) North West Zone Power Generation Company (NWPGC)
Transmission	Power Grid Company of Bangladesh Ltd (PGCB): Only entity for High Voltage Transmission Operation
Distribution	Bangladesh Power Development Board (BPDB): Urban area of North, South and central zone (24 % of total Sales) Dhaka Power Distribution Company (DPDC): Dist. Operator for southern part of Capital City (20 % of total Sales) Dhaka Electric Supply Company Ltd (DESCO): Dist. Operator for northern part of Capital City (11 % of total Sales) West Zone Power Distribution Company (WZPDC): Dist. Operator for Khulna & Barisal Div. and Faridpur (6% Sales) Rural Electrification Board (REB): Responsible for Rural Electrification through 70 PBSs (39 % of total sales)

[18] http://www.powerdivision.gov.bd/

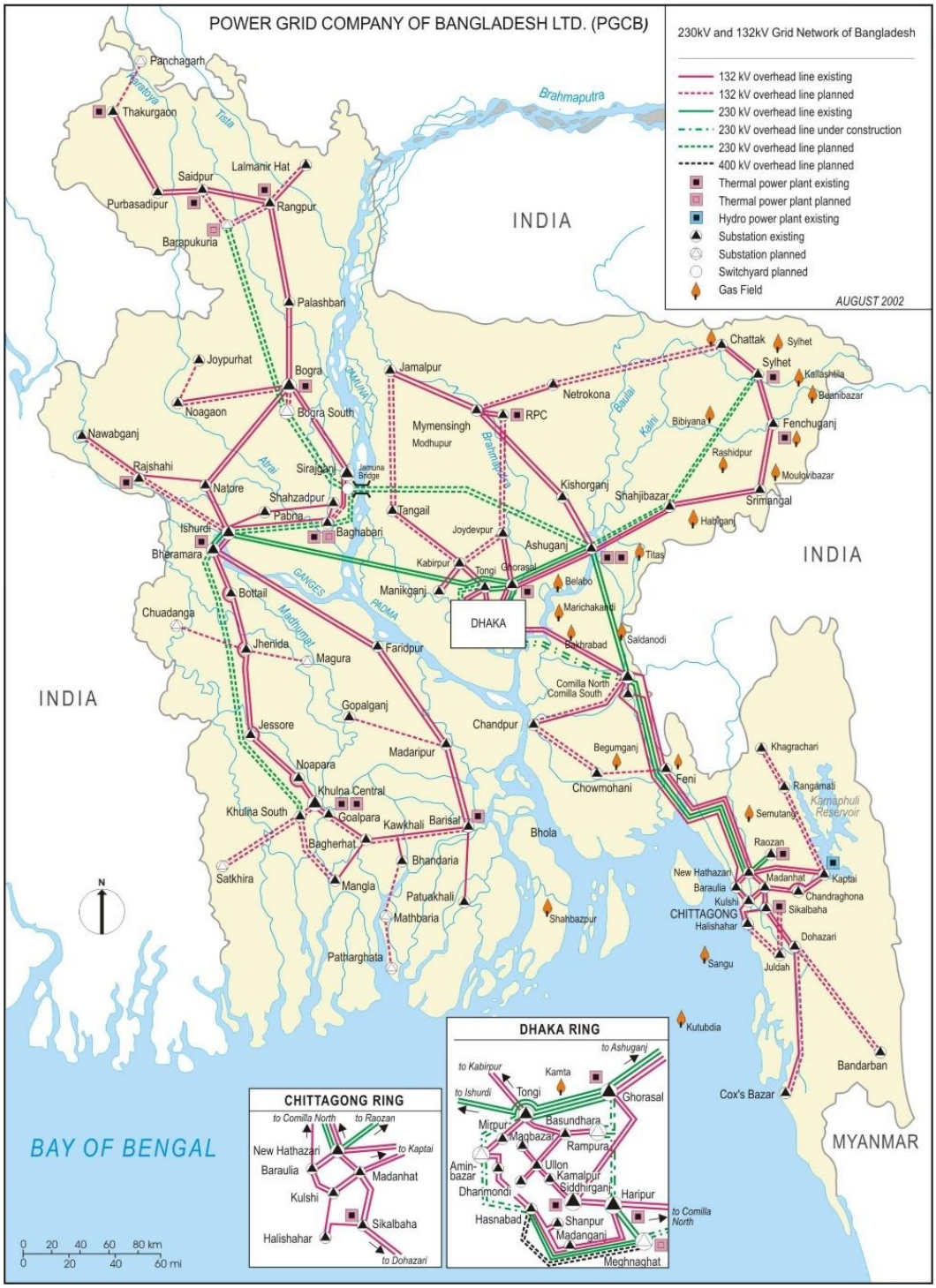


Figure 4:3 Power Grid Company Transmission area's map[19]

[19]Source:http://www.geni.org/globalenergy/library/national_energy_grid/bangladesh/bangladeshnationalelectricitygrid.shtml

At present, BPDB is functioning as a single buyer, except for some direct power purchase from small IPPs. For distribution, it has five entities. As Dhaka grew in population and became a metropolitan city, the need for its own electricity grid led to the creation of the Dhaka Electric Supply Authority (DESA) in 1991. DESA was created to operate and develop the distribution system and bring improvements in customer service and revenue collection, and also to lessen the administrative burden on BPDB. In 1991, the responsibility for power distribution in Dhaka was vested with the Dhaka Electric Supply Authority (DESA). Later, the Dhaka Power Distribution Company Ltd. (DPDCL) took over DESA activities in 2008, as part of an overall power sector reform that attempted to unite the energy system and produce more competitive, reliable and efficient networks. In 1994, the creation of the Dhaka Electric Supply Company (DESCO) also became part of the reforms. It is a public-sector company and a subsidiary of DESA.

4.3 The Power System Master Plan (PSMP): Diversification in Generation and Supply

The government of Bangladesh realised that to become a lower middle-income country, Bangladesh needs to maintain an annual 8% growth in GDP. The Power Sector Master Plan indicates that, to achieve this goal, electricity demand would need to be around 34,000MW by the year 2030[20]. Thus, Bangladesh is estimated to require around US$18 billion in power sector investments to minimise this demand-supply gap (source: Bangladesh Power Cell). As such, GOB has decided to build more power projects and diversify the power generation system. This is made possible by private sector and public-private partnership. Achieving energy security for the country, the GOB believes PSMP need to focus on three important areas: exploration, development, production, importing, distribution and sound management of different sources of primary energy; generation, transmission, distribution, cross-border trade of electricity; exploring renewable energy, and augmenting energy efficiency.

In 2010, immediately after taking power from the caretaker government, the current government published a road map for the power sector. This estimated that grid system demand would reach 33,708 MW by 2030: a massive increase from the existing generation capacity. The plan consequently stipulates the commissioning of a number of rental power plants as immediate measures to meet demand in the short term. The plan further envisages that, when the generation scenario improves with the completion of large-scale power projects, small generation units could gradually be de-commissioned. It is evident from the figures that

[20] https://policy.asiapacificenergy.org/sites/default/files/Roadmap_power_energy_en.pdf

capacity has grown rapidly over the last few years as a result. Favourable government policies have attracted private investment and Independent Power Producers (IPP), and at this moment 45% of total power generation comes from the private sector.

Table 4:4 Present Installed Generation Capacity (MW) as on 30 September 2017[21]

Public Sector	Installed Generation Capacity (MW)
BPDB	4402
APSCL	1508
EGCB	622
NWPGCL	718
RPCL	77
BPDB-RPCL JV	149
Subtotal	**7,476 (55%)**
Private Sector	
IPPs	3245
SIPPs (BPDB)	99
SIPPs (REB)	251
15 YR. Rental	169
3/5 YR. Rental	1721
Power Import	660
Subtotal	**6,145 (45%)**
TOTAL	**13,621 ***

Fuel Type	Capacity(Unit)	Total (%)
Coal	250 MW	1.84 %
F.Oil	0 MW	0 %
Gas	8529 MW	62.62 %
HFO	2794 MW	20.51 %
HSD	1158 MW	8.5 %
Hydro	230 MW	1.69 %
Imported	660 MW	4.85 %
Total	13621 MW	100 %

Derated Capacity

Fuel Type	**Capacity(Unit)**	**Total (%)**
Coal	170 MW	1.32 %
F.Oil	0 MW	0 %
Gas	7936 MW	61.41 %
HFO	2792 MW	21.61 %
HSD	1134 MW	8.78 %
Hydro	230 MW	1.78 %
Imported	660 MW	5.11 %
Total	12922 MW	100 %

[21]http://www.eblsecurities.com/AM_Resources/AM_ResearchReports/EquityReport/Bangladesh%20Power%20Sector%20Overview-%20October%202017.pdf

The BPDB has also taken initiatives to repair and renovate its 26 power units, which are 15 to 25 years old and have a total capacity of 1,679 MW. Steps have also been taken to set up substations and transmission lines at different voltage levels to transmit electricity generated in power plants to load centres. According to the Power Division of the Ministry of Power, a total of 57 plants (with a total capacity of about 4,432 MW) have been commissioned. 33 plants with a capacity of 6,569 MW are also currently under construction. 19 projects with a capacity of about 3,974 MW are underway and nine plants with a capacity of 3,542 MW are at initial stages. Access to electricity has been raised from 47 per cent to 63 per cent (including renewable energy), and per capita electricity generation increased from 220 kWh in 2009 to 321 kWh in 2013.

It is important to mention that the cost of electricity generation has increased due to expensive fuel (imported diesel or liquid fuel) being used for power generation on quick rental contracts. At present, the case for providing both implicit (off-budget), and explicit, subsidies for electricity arises since the bulk of retail tariff rates are set below the supply cost of electricity in both cases, in order to accommodate the high price of quick rental. Therefore, the BPDB, as well as electricity distribution companies, incur huge losses. The policy of reducing subsidies in electricity thus requires narrowing the gap between the sale prices and the supply costs. The government's approach has involved increasing the bulk and the retail tariff rates in a gradual manner (Table 4:5). This gradualist approach to price adjustments is intended to avoid large price shocks to the economy and to the mass public. It is assumed that by increasing the bulk tariff rate, the financial situation of the BPDB will improve (Mujeri et al., 2014). However, this also increases the supply cost of electricity at the retail level, having severe effects on the poorest users.

Table 4:5 Electricity Cost

FY	**Per unit cost (Tk. per kWh)**
FY2008	2.33
FY2009	2.53
FY2010	2.58
FY2011	4.20
FY2012	5.36

Source: Adopted by the author based on secondary sources

The third aspect that the PSMP has emphasised is exploring the potential for investing in renewable energy and in improving energy efficiency. It is argued that Bangladesh is endowed with a plentiful supply of renewable energy sources, including solar, wind, biomass and hydro-power. Bangladesh is situated in optimally for harnessing solar energy, due to its positioning between latitudes 20° and 27° N. This results in an average daily solar radiation of 4-6.5 KWh/m², and 300 days of sunshine a year (Urmee & Harries, 2011). The maximum amount of radiation is available in the months of March-April and the minimum is in December-January. The annual amount of radiation varies from 1840 to 1575 kWh/m2 which is 50-100% higher than in Europe (Habib & Chungpaibulpatana, 2014). Thus, solar energy has enormous potential to contribute to the power generation sector.

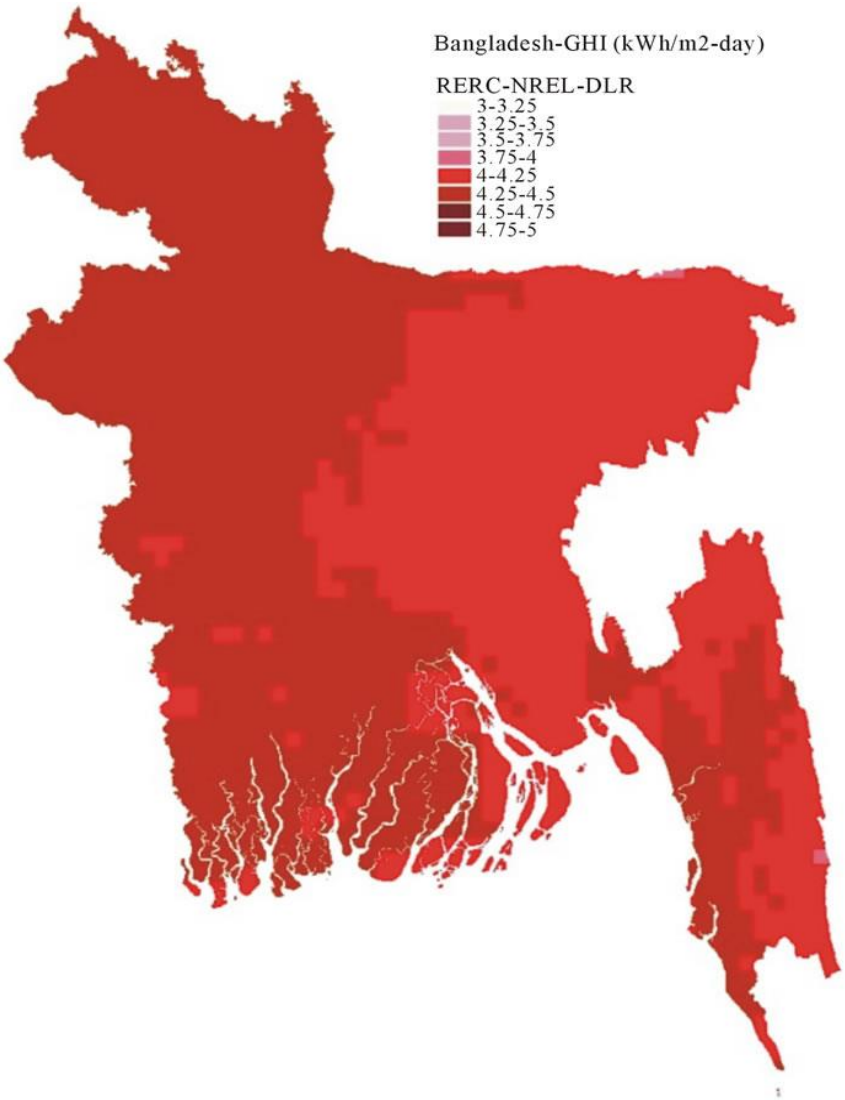


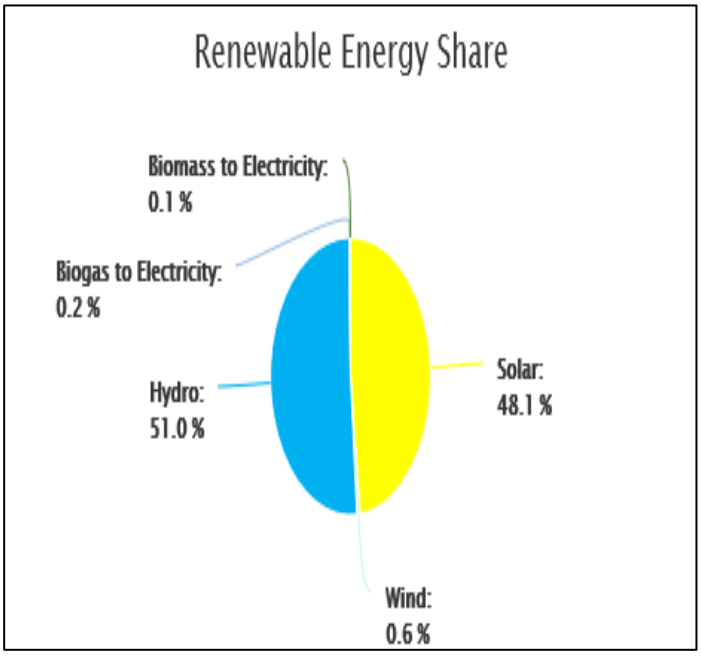
Figure 4:4 Solar radiation map. Source: SWERA, 2006

In addition, several locations in the coastal belt have been assessed to evaluate wind energy potential. The maximum average wind speed typically occurs during April (approximately 5.3 ms-1). The minimum occurs in December (around 2.6 ms-1). The technical potential of wind energy is estimated at 4,614 MW - lower than solar energy (Habib & Chungpaibulpatana, 2014). Due to a lack of reliable wind speed data however, the potential of wind energy has yet to be harnessed.

Finally, as an agricultural country, Bangladesh has considerable potential to harness electricity from biomass. Cattle dung, agricultural residue, poultry droppings, water hyacinth, and rice husks are widely available and can be easily used for biomass power generation. The total annual recoverable rate of biomass in Bangladesh is estimated to total around 126 mton per year. 50% of rice husks are already used for energy applications (such as domestic cooking and steam production for rice parboiling). Therefore, 50% of rice husks remain usable for power generation. Only 57% of poultry droppings are viable for small-scale power generation. The technical potential for biomass energy is estimated as 566 MW (Mondal, et al 2014). Due to the nation's flat terrain and potentially large social and environmental impacts, further exploitation of hydropower is expected to be limited. The estimated exploitable capacity for hydropower generation is 745 MW, of which around 200 MW is by small- and mini-sized hydro power plants.

Table 4:6 Current Share of Renewable Energy in Power Generation[22]

Technology	Off-Grid MW	On-Grid MW	Total MW
Solar	202.74	14.01	216.75
Wind	2	0.90	2.90
Hydro	-	230	230
Biogas to Electricity	0.68	-	0.68
Biomass to Electricity	0.40	-	0.40
Total	205.82	244.91	450.73



[22] Source: http://www.sreda.gov.bd/index.php/site/re_present_status accessed on 17/11/2017

4.4 Emergence of Solar Energy in off-grid areas

The government of Bangladesh has placed an enormous emphasis on ensuring efficient and sustainable electricity access to the citizens of Bangladesh since 2008[23], but achieving 100% electrification is not only expensive but also difficult, primarily because of the low-lying delta that is crisscrossed by hundreds of rivers. Decentralised electricity has consequently been considered an ideal solution (Thiam, 2011). This is not a new topic, but the provision of sustainable and secure renewable energy has recently gained priority in the light of current discourses of climate change and global governance strategies. Various international development institutions, such as UNDP, UNEP, European Union, KfW, GIZ and the World Bank, are actively accelerating decentralized energy supplies in developing countries. These development institutions offer the potential to confront energy poverty in an environmentally friendly way (Schäfer et al., 2011). A number of initiatives have been taken to diversify the sources of energy, and break away from dependence on gas, coal and liquid fuel for power generation since 2009. The Bangladesh Government aimed to produce 5% of total energy from renewable energy by 2015 and 10% by 2020. To achieve this goal, solar technology is considered the most viable solution because of the favourable geographical location and easily maintenance.

4.5 The journey of solar energy in rural areas

The solar energy programme in Bangladesh is considered one of the largest and fastest growing renewable energy markets in the world. Under this programme, about 4.12 million Solar Home Systems (SHSs) have been installed in remote areas where electrification through grid expansion is deemed challenging and costly. It is believed that the solar energy initiative has ensured supply of solar electricity to 18 million people (12% of the country's total population) who previously used kerosene lamps for lighting purposes[24]. The journey of the solar energy programme in Bangladesh has taken different routes since the beginning. Photovoltaic Solar technology was initially introduced in Bangladesh as an alternative source to eliminate darkness in emergency navigation and provide support in critical situations. The first appearance of solar power in Bangladesh was in a ferry terminal for navigation light in 1981. The Bangladesh Power Development board (BDBP) installed 55 PV powered signalling lights on 11 towers of the East West Interconnector in Aricha near to Dhaka, and the Bangladesh Inland Water Transport Authority (BIWTA) installed 125 PV powered beacon

[23] It is claimed that the current government (formed in 2008) has been given the energy sector highest priority for the country's development. Source: http://www.powerdivision.gov.bd/

[24] http://idcol.org/home/solar

lights in different parts of Bangladesh to identify marine routes at night in 1983, built with the support of the Norwegian Agency for Development Cooperation (NORAD).

As part of the government funded New and Renewable Sources of Energy (NSRSE) programme, the Bangladesh Atomic Energy Commission (BAEC - a scientific research organisation and regulatory body) carried out experiments with solar energy installations. In 1988, it conducted a Solar Photovoltaic Pilot project on Sandwip Island, involving a number of different programmes (Awal, 2000). These included:

Table 4:7 Installation of solar home systems in South Sandwip

April 1988	Disaster Management and Social Development Programme at Red Crescent Cyclone Shelter
April 1988	Hospital Program at Sandwip Hospital
April 1988	Solar Mosque
December 1989	Sandwip Livestock Hospital Programme

Figure 4:5 Pictures of Current Sarikait School and Red Crescent Cyclone Shelter Source: Author

Under this programme, BAEC installed a solar-powered beacon light on top of a watch tower, solar-powered refrigerators in a veterinary hospital for storing lifesaving vaccines, and solar light and microphones in a local mosque. However, a number of respondents interviewed as part of this thesis claimed that this BAEC pilot project was a remarkable event, not only for Sandwip islanders, but also in the history of solar energy in Bangladesh. It was considered a

milestone that demonstrated solar technologies' potential for dealing with a critical energy situation. On 29 April 1991 however, a cyclone caused extensive damage to the solar infrastructure installed upon Sandwip Island. Yet despite this, the solar panels in Sarikait Red Crescent Society Cyclone Shelter survived, contributing significantly to the response efforts conducted in the aftermath of the cyclone. As such, the project revealed solar energy to hold considerable potential as a technology for tackling future crisis situations (Awal, 2000).

4.6 Narsingdi Solar Energy Project of REB

In 1994, the Rural Electrification Board (REB) was commissioned to work on a pilot project funded by the French government. The project included four isolated villages in Nazarpur and Karimpur Island, in the Narsingdi district (Narsingdi is situated in central Bangladesh, located 50 km north east of Dhaka). It was the first large scale solar project in Bangladesh, costing 6.4 million French franc (grant money) and local currency of Tk. 2.70 crore was provided by the Govt. of Bangladesh, and providing a generation capacity of 62kw to a total of 795 consumer households. Narsingdi solar project introduced five categories of solar energy system. These are:

Table 4:8 Categories of solar energy system in Narsingdi project

System 1: Solar lantern, module with 11 watts of lighting
System 2: 2 tube lights (8w), 1 battery (60AH), 1 Socket for small radio/cassette player etc.
System 3: 2 tube lights (8W), 1 tube light (13W), 1 fan, 2 batteries (60AH), 1 socket for small radio/cassette player/tv etc.
System 4: 2 tube lights (8w), 1 tube light (13W), 1 fan, 2 batteries (60AH), 1 socket for small radio/cassette player/tv etc. with independent one 46 W module.
System 5: 2 tube lights (8w), 1 tube light (13W), 1 fan, 2 batteries (100AH), 1 socket for small radio/cassette player/tv etc. with independent two 46 W module.
There was an additional system for health centre: 2 tube lights (13w), 1 tube lights (8W), 2 fans, 1 refrigerator, 12 batteries (400AH), 1 socket with independent sixteen 46W modules.

The project is considered a milestone in the history of solar energy in Bangladesh because it helped experts to identify the appropriate systems of solar technology for the country (Eusuf, 2005). The initial concept was designed by FONDEM, a French company, and the equipment was supplied by Apex Ingeneurie, another French organisation. The entire project was implemented by Associated Resources Management Co. (Armco), a Bangladeshi Engineering firm. The project demonstrated the solar home system was the most popular: called systems 4 and 5 in the Narsingdi project. Later, a number of solar projects were initiated and implemented by different players.

Subsequently, the Local Government Engineering Department (LGED) has worked with BAEC to develop and operate PV systems in areas of social need or vulnerability, including multipurpose cyclone shelters, hospitals, institutions, communication centres etc. situated in remote and isolated areas. In 1996, the Red Crescent Society also installed PV power-based radio links in 52 cyclone shelters situated in the coastal belt of Bangladesh, as part of their 'Cyclone Preparedness Programme' (CPP). Moreover, under the Sustainable Rural Energy project, LGED introduced other forms of renewable energy generation in different areas of Bangladesh. The LGED's Sustainable Rural Energy project aimed to develop community-based models of renewable energy as an alternative source of rural energy in the off-grid areas of Bangladesh, demonstrating the viability of renewable energy technologies, building capacity for technology transfer, and widely disseminating these technologies in the off-grid areas. By 2007, LGED's installed diversified solar PV capacity reached 40.5kWp in off-grid parts of Bangladesh (source: LGED website). The Bangladesh Power Development Board (BPDB), which is responsible for planning, construction and operation of power generation and transmission facilities throughout Bangladesh, and for distribution in the urban areas, also implemented photovoltaic solar energy in the Chittagong Hill Tracts.

In summary, a large number of energy projects have been implemented in Bangladesh by different organisations over the last 50 years. A side-effect of this however has been the creating of confusion over who should have responsibility for pushing forward solar technology in Bangladesh. Should it be the Bangladesh Power Development Board (BPDB), the Ministry of Energy, the Atomic Energy Commission, or the REB (as solar energy is used in rural areas for off-grid electrification). This confusion began when the Bangladesh government received French government money to implement the pilot project in Narsingdi. (because the concept was to implement solar technology in rural off-grid areas, it was thought the Rural Electrification Board (REB) should provide support and manage this project). Later however, the REB became reluctant to implement solar energy technology because it was an unfamiliar

technology and they were faced with a lack of a support infrastructure and adequately trained employees in remote off-grid areas (Eusuf, 2005).

4.6.1 Solar Energy in Social Development Project: Creating rural entrepreneur

While the government was experimenting with different programmes to integrate solar energy in off-grid areas, Grameen Bank (the largest micro-finance bank in Bangladesh) formed another business venture called Grameen Shakti in 1997 to eliminate darkness in off-grid areas. The word *Grameen Shakti* is a Bangla word means 'rural energy' or 'village power'. As a micro credit institution, Grameen Bank realised that the social and economic development of its borrowers had been held back because of a lack of light in rural areas after dark. It consequently believed that micro credit would help borrowers to initiate business for the betterment or their lives (Wimmer, 2012). Through this project, the rural poor were seen as active individuals who could behave as entrepreneurs and risk-takers (Ferguson, 2007).

In July 1997, Grameen Shakti secured a loan from the International Finance Company, and started a solar entrepreneur programme. Grameen Shakti claims solar lights helped rural entrepreneurs like grocery shops, pharmacies, barbers, tailors and carpenters to increase their income by working long hours after dark. Later, it secured funding from the Rockefeller Foundation and the Stichting Giles foundation for its solar home system programme. In addition, another leading NGO, BRAC, joined the solar energy programme a year later. With financial support from the Global Environment Facility (GEF), BRAC initiated a similar kind of project from the Energy Services Delivery (ESD) programme, as part of their social development services. The project ran from 1997 to 2002, and is believed to have harnessed the potential of the country's dynamic private sector to complement government efforts to address urgent rural electrification issues (Sovacool & Drupady, 2012). In other words, it initiated a political shift toward international development agencies promoting private sector actors to fulfil the neoliberal agenda of the Washington consensus, inspired by the discourse of development.

4.6.2 RERED Programme: Bringing light to rural people's homes

After international development agencies realised that neither private companies nor the state had the will or ability to provide electricity access through conventional grid extension activities, these agencies conducted a number of policy reforms in which decentralised solar energy technologies emerged as a mainstream solution to providing electricity access to off-grid areas in developing countries (Gent, 2014). In 2002, the World Bank decided to support the Bangladeshi government to raise levels of social development and economic growth by

increasing access to electricity in rural areas through investment in small-scale solar energy technologies. Following the IDCOL's pilot project and REB's working areas of expertise, the it decided to implement the Rural Electrification and Renewable Energy Development (RERED) project, with the assistance of both organisations. An initial target was set for the programme to reach a target of 50,000 SHS to rural people by the end of 2007. The project reached this target 3 years ahead of schedule (Rahman, 2012). However, the REB's performance was not satisfactory, due to the weakness of their networks in remote villages. The programme with REB was consequently closed within its first phase. IDCOL managed to achieve the target successfully through micro-financed NGOs, as they had already established networks in rural areas. It is believed that this pilot project then successfully drew the attention of a large number of International Donor Agencies to finance solar home systems, including The World Bank, GEF, ADB, USAID, CIDA etc. It acted as a 'Flagship Venture' that encouraged investment in a series of other PV and Renewable Energy Projects by public, private and NGO Institutions.

4.6.3 IDCOL's Solar Home System Programme

As a mediator, IDCOL's success in solar energy programmes not only encouraged the World Bank to continue the RERED project until 2018 but also branded this project IDCOL's Solar Home system project where IDCOL accumulates money from other international donor agencies who were also interested in funding this solar home system programme. It is believed that solar energy in Bangladesh received a boost when Infrastructure Development Company Limited (IDCOL) stepped into the solar energy market (Sharif & Mithila, 2013). Currently, IDCOL primarily promotes two different projects: large and medium project infrastructure, and a renewable energy project. Under these categories, IDCOL runs five specific programmes. These are: financing (and arranging finance for) large and medium-sized infrastructure projects to be implemented by private sector actors, working as a Facility Agent and Security Trustee under projects, refinancing micro credit provided by NGOs'/ MFIs and other private entities for promotion of renewable energy, providing finance advisory services to both financial and project sponsors, and organising training courses on project finance and financial modelling. Following map (Figure 4.6) presents a clear picture of solar energy expansion in all over Bangladesh.

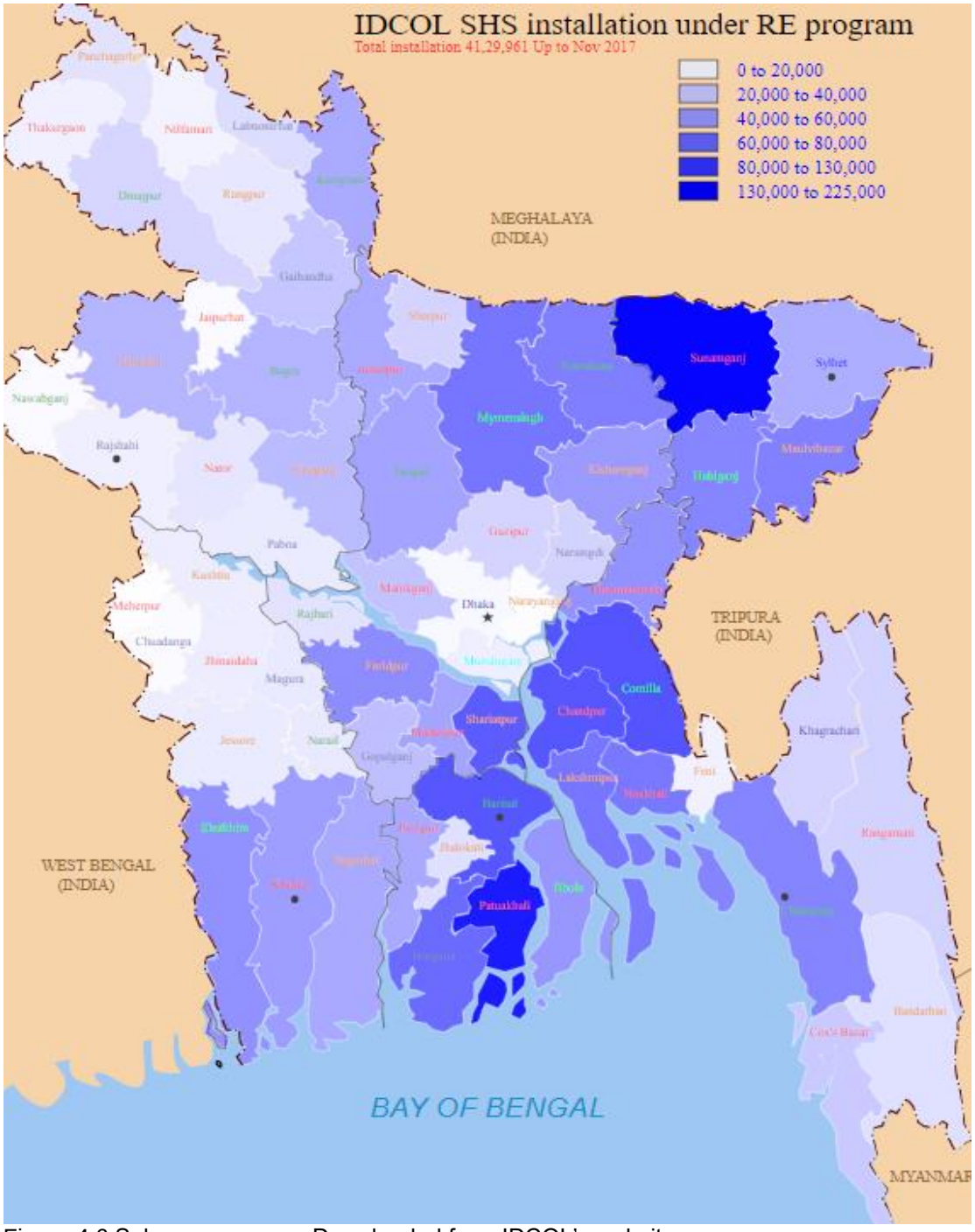


Figure 4:6 Solar energy map. Downloaded from IDCOL's website

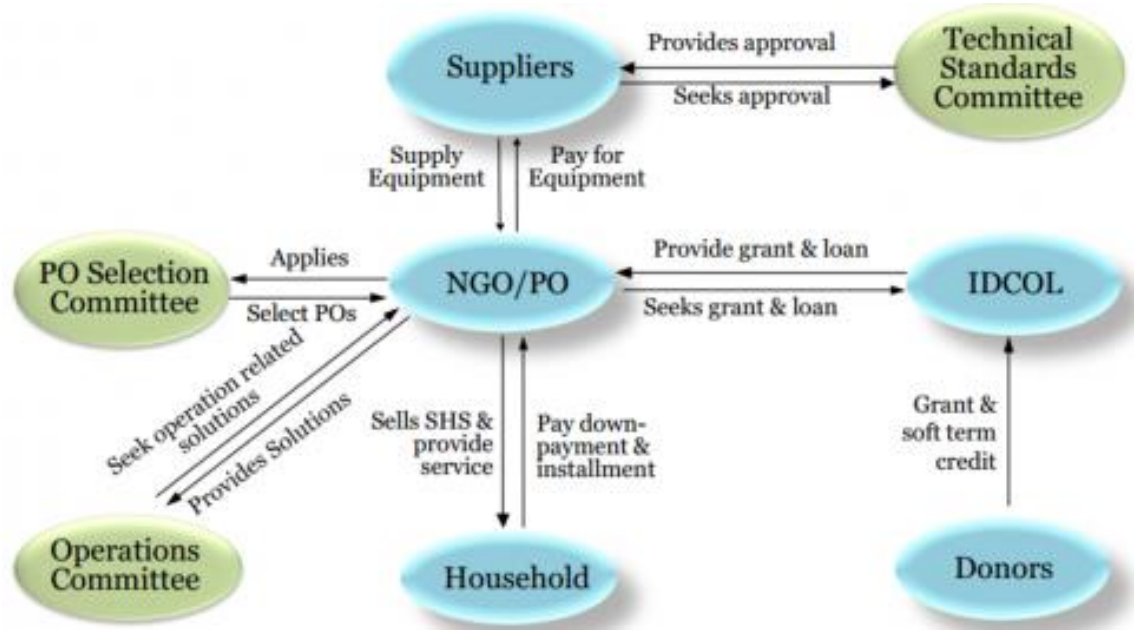


Figure 4:7 Working practices of IDCOL Solar Home System Programme. Downloaded from IDCOL's website

Figure 4:7 presents the working practices of IDCOL solar home system programme. IDCOL secures grants and soft term credits from multiple donor organisations and provides grants and loans to partner organisations (PO/NGO). POs then buy solar home system supplies and equipment from the IDCOL's listed suppliers, and sells solar home system solar home system SHS as well as providing services to off-grid areas. IDCOL has three separate entities: the PO Selection Committee, Technical Standard Committee and Operations Committee that work to manage to select POs, maintain the technical standards of the equipment, and provide operation-related solutions on the ground.

4.7 Emergence of Solar energy in On-grid Areas

Until 2009, expansion of solar energy was concentrated in off-grid areas. In 2009 however, a government decision was made to power lights and fans in the capital with solar panels (Energy and Power, 2011). To solve the urban electricity problem, solar (pv) energy appeared to offer a strategic solution. With the growth of rapid urbanisation and rising demand for electricity, the Bangladesh Power Development Board decided to stop giving new power connections to consumers for seven months. After this (from 1 November 2009), the government began granting connections to new buildings with the condition of having solar energy panels on rooftops. Thus, solar energy came to the urban landscape as part of the

solution to the power crisis. This policy required that all newly-constructed buildings included a rooftop solar power unit with an output of no less than 3% of the building's total peak load. However, it has been claimed that solar energy in the urban landscape is also part of the government's green initiative (Energy Road Map 2010). The immediate goal of this policy is to ensure a Load Shedding Free Bangladesh though.

It has been estimated that approximately 300 megawatts of electricity could be generated from 20,000 multi-storied buildings in Dhaka ('Rooftop solar systems can ensure uninterrupted power' reported in The Daily Star, 5-06-2010). It is believed that solar energy on rooftops could greatly help to ensure an uninterrupted supply of electricity that would mitigate against the prevailing energy crisis. Thus, the Ministry of Power, Energy and Mineral Resources has consequently decided to push forward this policy and prepare a new building code with a mandatory provision for the installation of solar panels on rooftops from June 2011. The draft set mandatory provisions for the installation of solar panels that could generate at least 2 percent of the total power demand of residential buildings and 5 percent of the demand of commercial buildings under the jurisdiction of Rajuk. To make this initiative popular, several public offices have also installed solar PV recently, such as the Prime Minister's office, the Bangladesh Bank (State bank of Bangladesh).

4.8 Conclusion

This chapter has outlined the organisation of the electricity sector in Bangladesh and the recent history of reform. The purpose of this overview has been to contextualise the emergence of solar energy in the country's power sector, outlining the current state of the electrical power crisis and describing the plethora of historical initiatives that have been introduced to solve this problem in recent years. We can broadly see from this history, a shift in paradigm. In the late 1990s and early 2000s, the statist model of energy governance gave way to neoliberal reforms that initiated privatisation and market liberalisation processes. This shift was rooted in wider economic policy shifts and transmitted through policy led assistance from international development organisations. The government of Bangladesh aims to provide electricity for all by 2021, but the expansion of the grid is both challenging and costly. Inspired by Sustainable Development Goals (SDG#7), and an influx of associated funding for low carbon energy, solar energy has been positioned as a primary means to achieve this development. The next chapter explores the impact of power sector reform on the low carbon energy market in Bangladesh.

Chapter Five: Making a Market for Solar Energy

Figure 5:1 Solar technology market in Sandarban, Dhaka

5.1 Introduction

The solar home system market in Bangladesh is considered one of the fastest growing renewable markets in the world (Sharif & Mithila, 2013). It is also said that the solar home system programme is the world's largest SHS programme, with about 5 million SHS installed, over 30 million people benefitting directly from solar energy, and over 100,000 new employment opportunities already having been created (The Dhaka Tribune 12/08/2017). According to Cross (2013), markets for solar energy do not simply emerge: they are made. Berndt and Boeckler (2009) argue that markets are continually produced and constructed socially with the help of actors who are interlinked in dense and extensive webs of social relations. This chapter approaches the solar energy market as a relational space that is "actively constituted through social and material relations" (Castán-Broto and Baker, 2017: 3). The value of this relational approach is that it informs an understanding of how energy can be governed, owned, regulated, produced, distributed and consumed, and it challenges the concept of energy as a neutral, technical and physical entity, revealing the multidimensional and multi-faceted nature of energy issues (Castán-Broto and Baker 2017).

Having looked at the changes and the reforms of the power sector in Bangladesh in the previous chapter (Chapter Four), this chapter focuses on the solar energy market. It identifies the actors, devices and social relations that constitute this market, and the continuous changes within it that have been shaping the uptake of solar home systems - and the solar transition more generally – in Bangladesh. In Chapter Four, I have demonstrated how international donor agencies strongly influence reforms to energy policy and how a market-led approach has become the main driver for economic development. The market-led initiatives and "allows for a more active and engaged state, but also recognises the role of civil society and local politics" (Ogbaharya, 2008; Silvery, 2010 cited in Schaaf, 2013: 126). In this chapter, I examine how these reforms have changed the relationship between the state, civil society and private organisations. I explore the complex array of knowledge practices, social relationships and meanings of the solar energy technology market.

The chapter is divided into three sections. Section 5:2 explores the implementation of the solar energy market, and the way in which the solar energy market in Bangladesh has been created. Section 5.3 focuses on the market in practice, and Section 5.4 identifies and explains the unintended consequences of the processes of creating a market for solar energy technologies.

5.2 Implementation of Solar Energy Market

Solar energy has emerged as a leading alternative to grid-based rural electrification in the Global South. According to Jacobson (2007), solar photovoltaic technology emerged as an important tool for rural electrification at a time when neoliberal policies dominated mainstream development thinking. It is argued that in the late 1980s and early 1990s, mainstream development policies emphasised economic liberalization, privatisation, and market-based approaches to service provision (Kapur, Lewis, & Webb, 1997). It is true that in the beginning of solar energy programme initiative, the World Bank adopted the practices and mechanisms that local NGOs had been using to promote renewable energy in off-grid areas as part of their development programme. However, the impact of ‘‘market triumphalism’’ (Peet & Watts, 1993), affected the whole development mechanism. Influenced by the development organisations, a market-based approach has been chosen to establish a successful solar energy market. This section explains the implementation of a solar technology market in Bangladesh.

Since concerns about the environment and rural development are dominant in the discourse surrounding solar electrification, market-based approaches have emerged as chief drivers for solar technology dissemination (Gent and Tomei, 2017; Marshall et al., 2017). Solar technology discourse is often framed using populist ideas like “small is beautiful” and “self-reliance” (Jacobson, 2007), with an emphasis on rural electrification. During the time when solar energy emerged in Bangladesh as a part of the rural electrification programme, NGOs, especially micro-credit organisations, were at the peak of their influence. When Infrastructural Development Company Limited (IDCOL) started the solar energy programme as a part of the Rural Electrification and Renewable Energy Development (RERED) programme, it initially decided to work with micro-credit NGOs. Although the RERED programme used to have different mechanisms in developing countries (Palit and Bandyopadhyay, 2016; Sovacool, 2013), I was curious to know why micro credit NGOs were chosen as IDCOL’s partner organisations (POs) to implement the programme. According to a solar energy expert, who has been working in renewable sector from the beginning Reza Chowdhury, the *“reason for choosing micro-credit NGOs as partner organisations was entirely practical. NGOs have access to remote areas; they have strong networks in rural areas, thus to work in remote rural villages, micro-credit organisations are the best option”*. As Abdul Halim, the manager of Agroni, a microcredit NGO that now works as a part of the IDCOL solar home system programme, elaborates upon this:

“*As we have micro credit programmes in rural areas, our staff collect information about prospective clients, for instance the village doctor, school teacher, government officers,*

madrassa (religious school) teacher, solvent service holders…, but not lower-income people. These people fall outside our target. After collecting data, field officers select and go to those prospective clients and try to convince them. We usually explain to them how useful solar is. If the household has children who go to school, we try to persuade them that it would be better for their children's study."

"NGOs are very important in this programme because we have experience in collecting money from rural people. Very few customers come and pay without asking: if they are coming to the bazaar (village market), they pay. But in most cases, we need to pay visits again and again. Therefore, only NGO people have this skill to collect money from these difficult customers. That's why I call this "push, sell and tough business".

At the initial stage, it was important to make people believe that objects like a plate can produce electricity and run lights, TVs and other electronic appliances. Wimmer, (2012) mentions that "the villagers used to think this is magic and the NGOs workers are conning them with their trick". In the initial stages of the programme, I was told how it was vital to get information about prospective customers, including who can really afford electricity, which families have a stable job or income, which families have electronic appliances already, and which families have children who go to school? This kind of information is important for ensuring that a product captures a market. Hence, micro-credit NGOs work closely with the community, and it is believed that their network could help the programme to reach its potential customers.

Nevertheless, many respondents who work in NGOs, or in international donor organisations, proudly claim that the IDCOL solar home system programme is an adoption of locally-grown practices that the micro-credit NGOs' were using before the donor-driven programme had started. Sabbir Khan, a financial expert who works on a solar energy project in a leading international development organisation, believes that solar home system programme in Bangladesh is a home-grown idea, the Bank just provides the funding for their idea. It sounds like Sabbir Ahmed wants to establish the point that the Bank has little control over the programme. He believes IDCOL, state own non-financial Bank, works as a mediator between NGOs and private organisations, is entirely self-regulating and takes all of the decisions on behalf of the state. Here it is important to note that the independence of IDCOL is debatable, as this kind of apex financial intermediary is typically established by donor organisations (Roy, 2010). Ashish Gupta, an employee of a leading micro-finance and solar energy NGO believes that organisation like IDCOL has no bargaining power, they are just a "puppet of donor

organisations". Here I argue, the role of IDCOL is mainly that of a guarantor of contracts and of a ''referee'' in disputes between the donor and the partner organisations (Stiles, 2002).

It is worth mentioning that the RERED programme of the World Bank was implemented in several other locations. For example, in Sri-Lanka, the RERED programme implemented a "double hand model", meaning solar consumers had to obtain the financing from the private credit institutions (PIC) and procure solar home systems from solar firms (Laufer & Schäfer, 2011). Until 2010, the RERED programme in Sri-Lanka was considered the most successful solar home system programme (See: Miller, 2010). Inspired by Miller's book Selling Solar (2010), when Turner (2015) went to investigate the success of the RERED programme, she found a different reality- she could hardly find a solar home system that are in operation. Patil (2013) argues that, since the solar firms were not responsible for getting repayment of loans, and since payment default did not directly impact them, they were less interested to the after-sales services. Ultimately, PCIs had to bear the brunt of the poor service, as delays or failures in providing the service directly impacted the loan repayment. In contrast however, in Bangladesh, the micro-financed NGO initiated a "single hand model", where solar consumers obtained the financing and procured the solar home systems from micro-financed NGOs. It is believed that this "single hand widow[25]" model is more appropriate to address users' needs and to assure functionality of the technical system during the period of loan repayment as observed from Bangladesh" (p.276).

5.2.1 Taking the Bottom-up approach: scaling up by alternation

The RERED programme in Bangladesh has been following the same single-window model that the micro-finance NGOs were using for the ESD project (discussed in Chapter Four, Section 4.3). Initially, only non-profit organisations were permitted to take part in this programme. However, a gradual change was brought into the system concerning the scalability and sustainability of the programme. Influenced by the neoliberal development ideology, market-based approaches were considered for ensuring the sustainability of the solar energy programme. According to an expert with longstanding connections to the solar energy programme in Bangladesh, *"the solar energy programme has always wanted to create a market";* mainstream neoliberal-thinking on the benefits of a market-based approach, and the expansion of capitalist markets, shaped the solar energy programme around the world (see Jacobson, 2007).

[25] Researchers often use different terms to describe the different models between Sri-Lanaka and Bangladesh

In 2006, Rohimafrooz, the sole battery provider of the IDCOL solar home system programme, established the Rural Service Foundation (RSF), a non-profit organisation, as part of their corporate social responsibility programme, and became part of IDCOL as a PO. From looking at the timeframe this occurred over, it is apparent that IDCOL's solar energy programme was only open to non-profit organisations until 2007 (first phase of RERED). After 2007 however, a number of private organisations who used to supply solar equipment started forming separate organisations to join the IDCOL's solar home system programme. The SolarEn Foundation (a solar energy equipment supplier), and the Rimso Foundation (Rimso Battery), became POs of the IDCOL solar home system project in 2007 and 2008 respectively. Types of POs in IDCOL's solar home system programme as below (Table 5:1)

Table 5:1 Types of POs in IDCOL's solar home system programme

Lender PO	A PO that extends loans or micro-credit to households in the subproject areas
Supplier PO	A PO that supplies approved solar equipment to households in the subproject areas
Supplier and Lender PO:	A PO that supplies approved solar equipment and extends loans or micro-credit to households in the subproject areas

When the solar home system programme started in 2003, IDCOL provided funding only to 'Lender POs' (micro-credit NGOs). Later however, when the programme became effective and the World Bank wanted to extend funding to the RERED project, it was suggested that IDCOL should include business organisations that had been supplying solar energy products to NGOs as Supplier POs. From the late 90s onwards, neoliberal motifs and a concern for energy poverty increasingly encouraged corporate actors to integrate social, environment and development challenges in their business strategies, claiming that these initiatives minimised ecological impacts, improved lives and livelihoods, and eradicated poverty (Prahalad and Hammond, 2002, Hart, 2005, Kandachar and Halme, 2008). Cross (2013) argues that "solar is an object that has been built as a response to the failures of states, markets and civil society to care for or safeguard the health of their populations and which expresses a humanitarian sensibility or an ethic of 'concern for distant others'" (p. 180).

Knowing that there are more than 22,000 NGOs working in different sectors in Bangladesh, I was curious to know why IDCOL decided to work with profit-based organisations. An IDCOL

official gave two reasons: firstly, NGOs do not have the capacity to feed the huge demand for solar energy in Bangladesh; and secondly, to ensure the sustainability of a market there is no alternative to private actors. Thus, private organisations eventually gained attention, and IDCOL decided to make provisions for the third types of POs: for-profit organisations, who could work as both lender and supplier POs in the programme. Here we see new attempts to capture and shape the market of solar technology by allowing new actors as development agents (Blowfield & Dolan, 2014).

5.2.2 The financial mechanism of IDCOL's solar home system programme

While solar energy advocates decided that solar energy was the ultimate source of development for rural off-grid communities, it also identified that financial hindrance is the biggest barrier for the dissemination of solar energy in developing countries (Martinot, 2001; Mondal, et al. 2010). According to Gupta (2012), due to the high-risk perceptions associated with new technologies, renewable energy projects often face financial difficulties (p 171). To overcome this barrier, international donor organisations are committed to providing support to developing countries' market agents. In this section, I present the financial mechanisms that have been developed to make a sustainable solar energy market with the help of international donor organisations in Bangladesh.

IDCOL offers several types of financial support to its POs. It provides capital buy-down[26] grants to reduce the cost of approved solar equipment to the supplier PO and lender/supplier POs. In addition, the lender POs receive capital buy-down grants, institutional capacity building grants[27] and refinancing (Aziz, et al, 2016). It also offers soft loans with a 10-year maturity and a 2-year grace period at 6% interest per annum to its lender/ supplier and lender POs, in order to manage its loans and micro-credit services in the solar programme. An IDCOL loan covers 80% of the micro-credit extended by its PO to the households for purchasing SHSs. Various loan tenures have been set depending on the nature of the project and the life of the assets financed.

These are:

- Senior loan: a maximum of fifteen years including four years' grace
- Subordinated loan: a maximum of twenty-three years including eight years' grace

[26] ***Grant-A*** Capital Buy-down grant to lower the initial investment cost of SHS

[27] ***Grant-B*** Institutional Development grant for capacity building and institutional development of POs. Grant-B is available only to those Lender POs whose aggregated number of approved SHS is less than 5,000.

- Refinancing facility: a maximum of ten years including two years' grace.

As such, the IDCOL solar home system programme is influenced by neoliberal ideas: it has involved the development of a financial mechanism in which grant money becomes reduced with the progress of the project. Specifically, the grant has declined in the following pattern (Table 5:2)

Table 5:2 Grant for POs for the Solar Home System Programme

Item	Source	Number of SHS Financed	Amount of Grant Available per SHS[28]		
			Total	Buy down grant	Institutional development grant
First 20,000 SHS	GEF	20,000	USD 90	USD 70	USD 20
Next 20,000 SHS	GEF	20,000	USD70	USD 55	USD 15
Next 35,000 SHS	GEF	35,000	USD 50	USD 40	USD 10
Next 88,160 SHS	KfW	30,000	EUR 38	EUR 30	EUR 8
	GIZ	58,160			
Next 35,000 SHS	KfW	35,000	EUR 36	EUR 30	EUR 6
Next 238,659 SHS	KfW	135,000	EUR 34	EUR 30	EUR 4
	GIZ	103,659			
Next 161,543 SHS	KfW	103,000	EUR 28	EUR 25	EUR 3
	GPOBA(DFID)	58,543	USD 36	USD 30	USD 6
Next 443,520 SHS	KfW	99,018	EUR 22	EUR 20	EUR 2
	GIZ	24,359			
	GPOBA (DFID)	178,103	USD 28	USD 25	USD 3
	GPOBA (SIDA)*	65,380			
	IDA	63,400			
Next 536,028 SHS)	GPOBA (SIDA)	185,550	USD 28	USD 25	(USD 3 for new POs only)
	GPOBA (SIDA)	350,478			
Next 305,000 SHS**	GPOBA (SIDA)	95,000	USD 23 Nil	USD 20 for small SHS (USD 25 for new POs only)	(USD 3 will be paid for new POs only)
	ADB (ACEF& CCF)	90,000			
	IDA	120,000			
	GIZ	73,858			
Total		1943508			

In addition, IDCOL also provides loans for refinancing the programme. Refinancing of loans is offered to households by the POs for purchase of SHS. IDCOL provides micro-credit extended

[28] There are two types of grant that IDCOL provides to the POS: Capital Buy-down grant and Institutional Development grants

by the Lender POs to the households to purchase a SHS. Refinancing of 80% of the loan amount is then provided to the POs, of which the combined refinancing amount from IDCOL is equal or less than BDT 25 crore (BDT 25,000,000) (not exceeding US$285/SHS/household). As with grants, IDCOL plans to gradually reduce the refinancing amounts. For POs with aggregate refinancing amounting to more than Tk.25 crore (BDT 25,000,000), IDCOL refinancing will be 70% of the loan amount dispersed in 2012 and 60% in 2013 and 2014.

Table 5:3 Various components of a typical 20Wp SHS investment are illustrated below, with a hypothetical example

Item	*Tk*	*USD*
SHS cost	12,000	150
Equity (10%) of system cost	1,200	15
Buy-down grant (US$20)	1,600	20
PO loan to household	9,200	115
Refinancing from IDCOL (80% of PO Loan)	7,360	92
PO Equity (20% of PO Loan made to households)	1,840	23
Institutional development grant (US$3)	240	3
** Exchange rate, USD 1 = Tk. 80*		

Table 5:3 shows a gradual reduction of grants from the IDCOL solar energy programme. The table also demonstrates how, as a high official of IDCOL explained, *"the free market economy policy suggests gradual withdrawal of donors' financial support when it is assumed the market is fully formed and does not need any further support… the solar energy market is now fully formed".* For example, KfW stopped funding for solar home system programme when the programme installed more than five hundred thousand solar home systems. Here we see that multiple donor organisations participated in this programme at different times. Several respondents in this study who had been actively involved in the dissemination of solar technology explained how it had been argued that the IDCOL's solar home system programme has matured as an independent market and does not need any further external support. Therefore, some of the donor organisations have already stopped financing the solar home system programme and the key player, the World Bank, will finish the RERED project by the end of 2018.

Donor organisations believe that the solar energy programme is fully developed and that the way this programme is supported by POs (both non-profit and profit organisations), has been developed to the point of financial independency. However, some respondents had a different perspective on the sustainability of the programme in the event of the withdrawal of financial assistance. According to Mujubur Rahman, an NGO employee, *"it is true that the solar energy programme has been obtaining financial support since 2003, and most people would say that it is long enough to develop a sustainable programme or a market. But we work in this sector and we can see a lot of problems in this programme and the way it designed".* He continues by saying that, *"big NGOs or organisations that have been part of IDCOL's solar home system programme from the very beginning, because they saved a huge amount of grants throughout the years, these big shots can survive without any support. But I don't think small NGOs or newly joined POs of IDCOL have gathered enough money to work for solar energy without any support".*

He also has some reservations towards IDCOL's solar home system programme design and practices, arguing that*, "as a donor-funded project, IDCOL always set a target and time limit for a highly ambitious number of solar home system installations under their programme. It is IDCOL's strategy to attract the donor organisation with their highly ambitious targets; and when they set a target, they need help to do it, so they add new POs. In this way, a number of organisations have been part of IDCOL's solar home system programme as POs. So now the question is: Are these NGOs or POs able to save enough money for their future?…You can see my point, right?"*

It is true that if we look at the reports, documents and websites from organisations that have been working in this sector, we often see that they claim the success of the programme to be mainly based on the massiveness of the market size of solar energy technology (see Asaduzzaman et al., 2013). Several blog posts on the World Bank's website[29] often refer to the number of solar home systems. These figures are then used to justify the need for solar energy in developing countries. For example, when IDCOL started the solar energy programme in Bangladesh as part of the RERED project in January 2003, the initial aim was to understand if the programme had a future in Bangladesh, by trialling the financing of 50,000 SHSs by the end of June 2008. In several reports and interviews that I conducted during my fieldwork in Bangladesh, IDCOL officials, or leading donor agencies, frequently referred to this achievement as a success (the initial target having been achieved 3 years ahead of schedule with only 6 POs). Based upon this 'success', the World Bank decided to continue the RERED

[29] http://blogs.worldbank.org/endpovertyinsouthasia/solar-home-systems-lighting-bangladeshs-countryside

project and set a new target to install 200,000 SHSs by the end of 2009. The success of some systems not only impressed the World Bank; it also earned admiration in the international development community as an exemplary programme. Thus, the World Bank continued on to the second phase of the RERED programme (RERED II) and decided to provide financial support until December 2018.

Table 5:4 IDCOL's Partner Organisations over the years[30]

Year	Number of POs	Types of POs
2002	5 POs	Non-profit organisations
2003	8 POs	Non-profit organisations
2004	10 POs	Majority non-profit, since 2006 for-profit organisations took part as a separate organisation from their main business
2009	15 POs	Both for-profit and non-profit organisations
2012	29 POs	Both for-profit and non-profit organisations
2013	47 POs	Both for-profit and non-profit organisations
2016	56 POs	Both for-profit and non-profit organisations

Table 5:4 presents the number and types of IDCOL partner organisations in the solar home system programme. The table also shows how the solar home system programme has gradually opened its door to private organisations, and that after a steady growth from 2009 onwards, it has been developing exponentially. The following Figure (5:2) illustrates the growth of IDCOL's solar home system programme. It also demonstrates that the rapid growth of the solar home system programme began in 2009/10, when the first phase of the RERED programme was about to end.

[30] This table is made by the author based on the documents, report and interviews

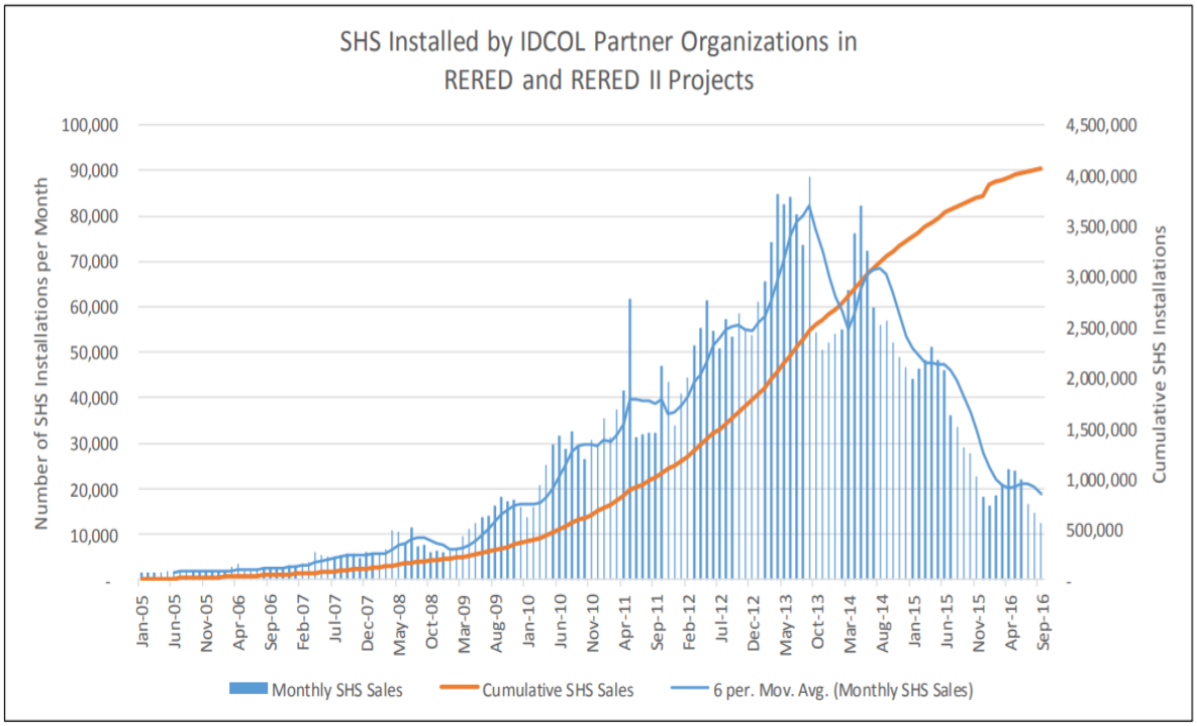


Figure 5:2 IDCOL solar home system programme growth, source: the World Bank report[31]

The increase in international donor support for solar electrification is widely associated with concerns about the environment (Martinot et al., 2002), especially global climate change, as well as rural poverty in developing countries (Jacobson, 2007). For the last couple of decades, solar energy has been considered a life-changing technology for people living in the developing world, especially for those who are living in un-electrified areas. As such, solar energy has become a major focus for the international donor organisation. In the above section we can therefore see how international donor organisations have developed mechanisms to create a sustainable solar energy market in Bangladesh. The following section investigates the impact of the creation of this market on everyday market relations and market practice.

5.3 **Market in Practice**

Having looked at the logic and implementation of the solar energy market, this section looks at the market in practice. As I discussed in the previous section, the creation of a solar energy

[31] http://pubdocs.worldbank.org/en/699871481690102550/pdf/RERED-II-AM-Oct-2016-Final.pdf

market is an outcome of a wide array of concerns and interests, politics, moralities and ethics (Cross, 2013). The market also takes the form of a sociotechnical 'agencement'[32]; a combination of material and technical devices, texts, algorithms, rules and human beings that shape agency and give meaning to action (Callon, 2007: 319). Thus, as Callon (1998) suggests, rather than separating the market model and market practice, in this section I explore market in practice as a part of market implementation.

5.3.1 Solar Panel Manufacturers

The most significant impact solar market implementation brings to the energy landscape is the establishment of a solar panel manufacturing industry. The manufacturing[33] of solar panels in Bangladesh is considered a milestone for many of the respondents interviewed in this thesis. Ali Zaker, an employee of a leading solar battery manufacturer proudly stated that before Bangladesh had to import everything from abroad, but now Bangladesh manufactures pretty much everything, even solar panels. Since 2009, eight solar panel manufacturer organisations have come into solar energy business. Continuous funding from development agencies for rural electrification projects, as well as the urban rooftop solar energy policy, has created an enormous potential in the energy sector in Bangladesh. Considering the size of this market, business organisations believe that establishing a solar assembling industry in Bangladesh could contribute to developing a whole new solar energy technology industry.

[32] The French word 'Agencement' means 'assemblage'. An assemblage/'agencement' consists of multiple, heterogeneous parts linked together to form a whole that an assemblage is relational. In Callon's work, 'agencement' is used as a relational effect of the practice of sociotechnical networks.

33 Solar panel manufacturers: are mainly solar module assembling plants. Based on imported solar cells, these companies assemble solar modules using semi-automatic machines.

Figure 5:3 Solar module assembly factory. Source: Author

There is a similarity among solar panel assembling companies: most of the assemblers are part of large private business organisations that have multiple concerns. For instance, Banoco Solar Energy Limited is one of the sister concerns of SAFE Property Development and Consultant Limited. It has two more businesses: ASSORT Housing and Engineering Ltd (a Real Estate business) and Harun Eye Foundation (an Eye Hospital). Similarly, Shouro Bangla is a sister concern of Chowdhury Group that owns businesses like Thai Plastic Industries Limited, K-line Air, Bay Consolidation, Chowdhury Securities ltd, and Neo Zipper Companies Ltd. Likewise, Radiant Alliance Solar is part of East Coast group; one of the largest business groups in Bangladesh. This runs businesses in trading, power generation, shipping, downstream petroleum, plastics & ceramics, real estate, wood treatment, corporate finance, banking, tea production and logistics (Table 5:5). However, considering the original businesses that these newly established solar panel assembling business had, it can be said that these companies typically have no previous experience working in the energy sector. From housing, to agricultural, or shipping businesses, these companies believe that the solar energy business is a new and profitable avenue in which to extend their business.

Figure 5:4 Solar panel assembly factories Source: Author

Table 5:5 Various solar panel assembling businesses.

Name	Original Business	Partner/ support
Baneco Solar	Real estate business	Italy/ German- business partner
Rohimafrooz	Energy storage and battery	China for technical support
Radiant Alliance	Shipping business	India for technical support
Paragon	Agro business	Taiwan-business partner
Shouro Bangla	Plastic	USA for technical support
GTS	New starter	China for technical support
Ava Solar	New starter	Spanish for technical support

Table 5:5 demonstrates two things: first, it shows majority of the solar assembling companies are part of large businesses and that all assembling companies draw upon technical support from outside of the country. One expert voice who is closely related to these solar assembling activities shares his dissatisfaction that nobody has made a serious effort to establish this business as a successful industry, as solar technology is a secondary business for most of the solar assembling companies. Therefore, the sector could not flourish, despite its potential. There is a popular argument about why most of the solar assembling businesses are part of larger businesses. For many, to establish this kind of business, one needs huge investment, and only large companies can afford this huge capital says Abdur Rahman, an employee of solar manufacturing company. It is true that to establish a solar assembling plant is expensive and technologically challenging, since this is a new industry. Therefore, with the support of large capital business organisations, the solar assembler companies can achieve the necessary financial support.

5.3.2 False Assessment of the Actual Market

Producing solar panel modules is a new technology for Bangladesh. Thus, the assemblers who decide to set up their own solar module assembling plants have to get help from outside of the country. An employee of a solar panel assembling company stated that they have really struggled to find a suitable partner: “We wanted to establish our factory for long term business and in a well-established form; however, what we felt was that they (foreign partner) were not keen to spend money for such an extensive and high-quality establishment. They tended to work with very basic and low-grade products”. Similarly, if we look at the table 5:5, Radiant Alliance limited works with Renewable Energy Corporation (REC) (a Norwegian solar company), as a strategic partner. Similarly, Parasol Energy has a Dutch partner. None of these companies have a smooth relationship with their business partners. In contrast, Radiant Alliance’s assembling plant was set up by an Indian manufacturing company who trained and provided all the technical support in its initial stages.

I had a number of conversations with solar assemblers who confirmed that this local-global partnership misinterpreted the market demand and most popular sizes of solar panels. As I have mentioned, most of these companies depend on foreign technical experts, and a lack of understanding of local markets became an issue for market control. If we look at the partners of these organisations (Table 5:5), most of them are European companies. Some respondents argue that European experts set up the machinery based on the most popular dimensions for panels in the European market- (which are typically large). In reality, large-capacity solar panels are perhaps ideal for urban rooftop solar usage, but are not ideal for a rural market.

Due to their high cost, the majority of off-grid rural residents would not be able to afford these kinds of solar home systems.

It is important to note that the market for solar energy in on-grid areas has not worked well, and became saturated within a year of its commencement. Since the rooftop solar policy failed to attract consumers, these consumers started making alternative arrangements to avoid solar energy installation, adopting various illicit practices (see Chapter 7). The number of units that were expected to be sold crumbled on the one hand, and, on the other, imported products of a low standard began taking over the industry due to there being no standardised mechanism to control product quality in the market. In fact, the market with most potential for solar technology market agents has turned out to be rural off-grid areas.

5.3.3 Interest Clash: Manufacturer vs Importer

Although IDCOL's financial support allowed POs to have grants to reduce solar device prices, and gave them access to loans to refinance the disbursement, the expenditure on solar equipment was high, as most of the equipment had to be imported from abroad. To overcome these difficulties and promote renewable energy (and especially solar energy), the government took initiatives to reduce prices, as well as to encourage market agents to get involved in this sector. As we have seen earlier in this chapter, several financial incentives have been put into place to encourage NGOs and private organisations to work in the rural electrification programme. After seeing constant demand from local importers, the government withdrew the import duty on solar technology items, the aim being to make them cheaper and more affordable so that solar consumers and market agents could benefit from them.

While this initiative helped the supplier POs to procure and sell solar equipment at a relatively reduced price, it also created another problem for local manufacturers. Until 2009, solar technology items were mostly imported. However, a number of local producers have recently started manufacturing solar devices in Bangladesh. The endurance of the IDCOL solar home system programme in off-grid areas, and the emergence of solar energy in on-grid areas, has encouraged local producers to get involved in this booming market. While a solar equipment importer can import solar products duty-free, local manufacturers need to pay import duty for importing raw materials for production. Thus, locally manufactured solar products are more expensive than imported solar products. Therefore, local manufactures have failed to capture the market for solar energy, despite the huge sales which occur every month in both rural and urban areas. According to Alauddin, the owner of a solar assembling company thinks that they h*ave the capacity to meet the country's total requirement of solar modules, but currently local*

producers manage to capture only one fifth of the total market because locally made products are more expensive than imported, substandard solar products.

Alauddin's claim shows that there are two problems: firstly, the higher prices, and secondly, the lower standard of the product. The standard of the product has become a particular issue in the solar energy market. Many respondents mention the poor quality of the solar energy products that have flooded the market. It has been argued that when the European Commission imposed an anti-dumping tariff on Chinese solar products[34], the Chinese solar producers needed a market where the standard of the product is not fully regulated (Lewis, 2014) . In addition, there is no facility to test the actual energy output of solar panels in Bangladesh, and substandard Chinese panels have consequently captured the market and have had a negative impact on the local manufacturing industry.

Figure 5:6 A closed solar panel assembly floor Source: Author

This picture (Figure 5:6) was taken at a closed solar panel's assembly factory. Towfiq, an employee here, showed me around. It is a small solar assembling plant consisting of several

[34] https://www.theguardian.com/business/2013/jun/04/eu-tarriffs-dumping-china-solar-panels

rooms. One thing that struck me during the tour was that there were no employees around, and no activities taking place. I asked Towfiq where the employees were, to which he replied that they had decided to stop further production until their previous production run was sold out. Towfiq showed me a pile of their finished product and informed that they will not go for further production until this pile goes to the market. I was also informed that the owner of that solar panel assembling company was thinking to sell the business, as the company is not making any profit from the business. It is important to mention while I was doing fieldwork, I learnt two other companies were looking for a buyer who can take over their businesses.

However, the local solar panel assemblers and accessories manufacturers have been trying to convince the government to pursue initiatives to protect local manufacturers, such as introducing provisions for mandatory use of local panels in government projects, as well as imposing duty on imports. Local producers believe that this will help the local industry to grow and will allow them to sustain themselves in an uncertain network. Nevertheless, some respondents expressed concern, saying that producing home grown solar items is not a good idea. According to Azmal Mahmud, a market analyst of the renewable energy programme who works in an international agency firmly believes it will not be a good idea to handover total power to the local manufacturers. For Mahmud if the local manufacturers are protected by the government, these companies would start having a monopoly. According to him ‘we are now living in the time of a free market economy: everyone needs to compete with each other and give the best to their consumers. Similarly, Saifur Rahman, a manager of a solar NGO, believes if the local manufacturers secure the total market, they may not care about services and quality of the products. If there is no competition, there won’t be any effort to improve products, maintain quality control and no fear of losing market share.

There is a fear and mistrust among the solar experts of protecting the solar industry and delivering it into the hands of local producers. On the other hand, lack of proper support and planning from the state to local producers is pushing the solar industry into danger. From these tensions it could be argued that the support that international donor organisations have given IDCOL’s solar energy programme to create a market has failed to support the local industry to make this sector a sustainable renewable industry.

5.3.4 The Rise of the Sundarban Solar Market

Since the start of my fieldwork in Dhaka, I had been hearing of a market called Sundarban; the largest electronic market in Dhaka. This market was referred to several times in interviews with solar panel manufacturers, and with solar energy technologies installers in on-grid areas. Although Sundarban market was known as an electronic market, now it is also known as a solar technology market. The pictures in Figure 5:7 were taken when I went to Sundarban market: they demonstrate how much solar technology items are dominating this location.

Figure 5:7 Solar technology equipment in Sandarban Market

Sundarban market sells a range of solar energy technology products, including solar panels, solar batteries, solar Instant Power System (IPS), DC light bulbs, DC fans and DC televisions. Shops in Sandarban market mostly sell solar products to those businesses that are not part of IDCOL's solar home system programme. As I mentioned earlier, IDCOL has formed a

standard list for solar technology products and only items from that list can be supplied by partner organisations (POs). The businesses in Sundarban market often get blamed for selling poor quality solar products; the most serious accusation levelled at the shops regards the forging of stickers on solar panels to show higher quality grades. In an unpublished paper[35], Sabbir Choudhury, the owner of Souro Bangla claimed that "average imported panels were over-declared at both ends; the exporter's and the retailer's. The combined over-declaration sometimes exceeded true input/output by 20%, where the international standard of power tolerance for panel is +/-3%". Similar practices were described by another local solar assembler, "to convince the consumers, some of the dishonest importers ask the exporter to oversize the modules and change the sticker according to the physical size, not according to actual capacity of the solar panel".

When I asked the shop owners in Sundarban market about the forging of stickers on substandard products, some owners admitted the problems and criticised the practice. Many argued that the most corrupt solar energy sector is the urban solar market. Since consumers are not willing to pay for solar technology, solar providers use this weaknesses and abuse it by implementing bad practices in order to be able to make a profit. The lack of a monitoring system in urban solar usage leads to the whole sector becoming corrupt from the start.

Mosharraf Hossain, a solar items importer and shop owner at Sunderban market shares his experience. When he went to China to buy solar items for his shop in Sunderban market, he visited several solar items shops and factories. During his visit the producers asked him what his budget for particular products was. If he tells them his budget, they can adjust the standard of the products.

Redwan Ahmed, a solar accessories supplier and urban solar provider says that *"China makes both good and bad products; depending on what kind of products does the business person wants: - good or bad*".

I asked him to elaborate on what he means by good and bad intentions, Redwan replied:

"*Well, by good intentions I meant a person who wants a long-term business relationship, cares about establishing goodwill in the business and is honest about the business. On the other hand, by bad intentions I meant those people who don't care about the solar industry, don't care about establishing long term business, don't care about good will: they only care that*

[35] Unpublished paper- supplied by the Author Sabbir Chowdhury on request

there is a business opportunity right now because of policy and donor funded projects, and they just want to earn some quick money".

Redwan added: "*it has a long-term impact on the sustainability of this solar market and I blame the government for not having a long-term vision… the government should have been more careful if they wanted to make it a sustainable market. The government has hardly any control over the market, control over the standard of the products or control over the different initiatives that have been taken to promote solar energy*".

The sentiments that Mosharraf Hossain and Redwan Ahmed shared are similar to the sentiments of other actors in the solar technology business. Both the government and donor organisations are blamed for not having a long-term vision for the sustainability of this market. Although solar advocates agree that, to ensure the sustainability of solar energy in developing countries financial assistance is needed, we have seen that financial support is mostly given to expand the solar energy market in rural areas, and that no assistance is given to local manufacturers. Meanwhile, the uncontrolled and unsupervised nature of the solar technology market has had an impact on the quality of the product, and local producers often struggle to capture market share due to the price competition with sub-standard imported products, mostly from China.

5.3.5 Alternative Strategies to Cope with the Uncertainty

Local solar producers have consequently started looking for alternative strategies to combat this uncertainty. Some solar assembly companies, for example, have decided to install a solar mini-grid project. Others are considering setting up production runs for smaller-sized solar modules so that they can produce solar panels according to the rural solar home system market. I was also informed that one local solar equipment producer had decided to extend the market by exporting solar panels to Africa. Another solar assembling company is also trying to increase sales through external agents. It has developed a new solar home system by taking into consideration the current constraints of the IDCOL's solar home system programme. The IDCOL solar home system programme has a strict rule that no fans will be allowed in the system. Understanding the demand for fans in rural households, Parasol solar developed a home system where a DC fan is included with a solar home system package (figure 5:8).

Figure 5:8 Parasol Solar's solar home system product. Source: Author

Towfiq expands on this situation:

They have been looking for alternative strategies to sell our solar panels; their team has been carrying out market surveys to find out where the gaps in the current market are. The team had identified that the biggest market for the company is in rural off-grid areas where other NGOs are working with IDCOL. Although some of the panel assemblers or solar equipment producers have been considering becoming a part of IDCOL's solar home system to secure the business. However, the owner of Towfiq's company is not interested in becoming an IDCOL PO, therefore they decided to work separately, with local entrepreneurs.

To follow up this conversation I asked Towfiq why does the owner of this company not want to become IDCOL's PO? Towfiq explains becoming IDCOL's POs is not easy: it needs to do a lot of paper work and also IDCOL has a lot of rules and regulations. He expands the IDCOL solar home system does not includes a provision for a fan, computer, laptop, however, these are the current needs and demands for many rural households. But when an organisation works as an IDCOL PO, it is not allowed to include these provisions in the system. Their survey report has identified these needs of rural households and decided to include the provision of these electronic appliances in their solar home system package.

I was curious with this newly developed solar home system package of Towfiq's company that he works in and asked him does he not think that demand for laptops or computers are only limited to a section of the rural population? Does he think by including this his organisation can have better sales than a PO? Towfiq agrees with me and says maybe I am right, but he thinks to have a provision for a fan is a demand for every household in rural areas, he believes that by allowing extra devices in their solar home system package, this will encourage many households to buy their product.

Figure 5:8 shows the devices that Parasol Solar includes with their solar home system package. Towfiq told me that they include a large-sized battery that allows some extra storage for using home appliances like a fan or computer. It is clear from his comments that local producers have developed alternative strategies to grab the solar market by exploiting gaps in the current market. In Sandwip I saw several shops that buy solar home systems from Sundarban market and that sell solar products both for cash and on short-term credit. However, several POs of IDCOL have accused these local entrepreneurs of sabotaging the solar energy market by buying cheap, substandard products and modifying solar home systems without considering the long-term consequences. Wahid, an NGO worker in Sandwip says: *"you may have seen a shop in Haramia Bazaar selling solar products, it is not part of IDCOL. That shop brings solar products from Dhaka, the quality of his products is not as good as IDCOL's solar home system; it is obvious that this kind of cheap products perform poorly or break down easily. When something goes wrong, people start blaming solar technology: the villagers do not blame him [the seller] for selling poor quality products, the villagers blame the technology and think that solar technology is not a durable product".*

In this section, I have presented the everyday practices of the solar energy market and demonstrated several practices and tensions among actors involved in this market. I have explained that, while some of these initiatives have helped local investors take part in this business and reduce their prices, this has also created problems for local producers. Thus, local producers have developed alternative practices and are using them to their advantage.

5.4 Unintended Consequences of Solar Technology Market Creation

Post-development scholars criticise the way that the development industry constructs development problems and introduces technocratic solutions that often ignore the complexity of political and social realities in a country (See Ferguson 1994). Ziai (2013) argues that "the classical paradigm of development constructs social problems (whose existence is not called into question) in peripheral countries as "development problems"; as problems linked to a lack

of capital, knowledge, technology, productivity, institutions, etc. that can be solved by projects or programmes of development which deal with these shortcomings" (p 129). Ziai highlights two main problems with this construction: first, that this perspective neglects the heterogeneity of the supposed beneficiaries, and second, that this perspective assumes that social problems can be solved with technocratic solutions – with solutions that are unconcerned with politics, relations of power and conflicts of interest, and that are rational and that no one can object to. Using the development projects in Lesotho, James Ferguson argues that political reality of a country, such as social class, bureaucracy and corruption, use of official position and power by elite, are generally ignored by development experts. The tendency of the development industry is to suggest apolitical, technical tools that inevitably result in failure (Schaaf, 2013). According to Ferguson, by ignoring the entrenched social and political context, development programmes often lead to failure and have unintended consequences. In this section however, I explore the consequences of attempts to create a large solar energy market. I also explore the unintended consequences of this solar energy transition on actors involved in this sector. Many of my respondents believed that while creating a solar market has led to the sale of a massive number of solar products and created several businesses, it has failed to ensure the quality of the products and services.

5.4.1 Target-Based Programmes

Winther (2013) argues that the success of a development programme is often measured by quantity. In the beginning of this chapter we saw that IDCOL's solar home system programme has always been target-based, with a fixed target number of solar home system installations being set at the start. In section 5.1, we saw that, over a year, IDCOL increased the number of POs to achieve its set targets. Nonetheless, these targets have had impacts on the quality of customer services and the quality of the solar technology products. According to Rasul, the manager of a solar NGO in the Maitvanga area*: "since we have targets every month, we cannot provide good services to all of our former clients who have already bought the solar home system from our organisation. We need to use so much time to fulfil the target and reach to new clients… I am sure that when you go to people's houses you hear a lot of complaints about us, what poor service we provide, how slow our response is when they have any problem with the system. This is because we have to sell a certain amount of systems to save our jobs."*

Rasul continues: "*if we can't sell a certain number of systems, my branch manager won't be happy with me; if all the branches fail to reach certain targets, then the regional manager won't be satisfied with the performance of the branches and if the regional manager fails to send a*

satisfactory sales report, then the head office won't be able to submit a satisfactory report to the IDCOL and get the reimbursement."

Rasul adds: "*This is all linked…thus our main priority is to sell as many of the solar home systems as we can to meet the targets*".

Similarly, Wahid, another NGO employee says: "*it is very difficult to provide quality service to old customers when we have so much pressure to add new customers*".

Lack of quality services and negligence came up several times in conversations with solar energy users. Some of these customers said that, even though they have the ability to pay the fee in cash, they have opted for a three year' credit contract so that the NGO staff have to pay monthly visits to collect the money. In that way, the buyers can get services if they have a problem with the system.

Another problem was identified during fieldwork, related to achieving these ambitious targets. IDCOL has been expanding their network to achieve these targets, encouraging both profit and not-for-profit organisations to come forward to work in this sector. However, some of the respondents I interviewed say that the programme has been expanded so fast that there are not enough skilled people who can work in this sector. This is a problem. When a private organisation decides to work in this newly developed market, they often hire experienced staff from other NGOs by offering a higher salary. Thus, there is a real crisis for this sector when it comes to offering good services to the field. For instance, Proful Kumar used to work for Grameen Shakti, the first and leading solar energy NGO for 15 years before he moved to be the head of a newly established solar NGO. Similarly, SolarEn, a Bengal solar company, hired a number of employees who used to work in different solar organisations.

Another concern that came up in different interviews was that, although IDCOL has set rules and regulations to ensure the sustainability of the programme, on the ground, NGO staff need to carry out a great amount of extra work in order to keep the goodwill of, and a good relationship with, locals. Many managers and officers confess that it is very difficult to follow all the rules and regulations of IDCOL. As a partner organisation, they try to follow as much as they can, but there are many cases where they need to break the rules to survive in the business. Some of the managers I interviewed in Sandwip disclosed stories about their illicit practices and justified, with logic, why they are doing this. In Aminul Islam's words: *"there are a number of competitors in this business on this small island. Once, customers had limited options, like Grameen Shakti (a solar energy company) or a few more. But now there are*

plenty of opportunities for the customers. So, if we cannot provide some extra facilities, why would the customer come to us?".

I asked them what kind of extra facilities they usually provide that can be considered as contravening IDCOL regulations. Ruhul Amin, the branch manager of a solar NGO on Sandwip, shared two cases where he did some favours to increase sales (he always has targets to meet from Head Office at the end of the month). By doing these favours, he has formed a good relationship with local users. In South Sandwip, he has allowed two customers to procure SHS for commercial purposes. It is not that IDCOL does not allow commercial customers, but the capacity a domestic customer can buy is limited to a W85 solar home system. Besides this, a household cannot get credit facility on its second purchase.

Furthermore, the solar company does not receive a subsidy for a second sale to the same household. It was difficult for me to make sense of this regulation; and so Wahid told me about lights and other facilities. A typical SHS comes with IDCOL's prescribed solar home system equipment, for instance the number of lights, length of wire, or other hardware equipment. According to IDCOL, the Technical Standard Committee (TSC) regulations fixes the numbers of LED and CFL lights permitted according to the size of the PV module. To satisfy customers however, sometimes the PO (NGO employees) add extra lights - on the condition that customers would not use all of them together. When I was on Sandwip, I followed several PO employees to observe the installation process and saw NGO employees ask the solar home system buyer if they wanted an extra dim light. If the buyer replied in the affirmative, they could buy the light and some extra wire from local shops, and the NGO employee would fix it while he was installing the solar home system. This is a common practice among almost all solar companies in Sandwip, as confirmed by Mujibur, a NGO employee: "*If the customers bear the expenses of wire and dim light, the solar engineer will install the light: this has become an unrecorded practice in most cases".*

Providing extra facilities is not only satisfying for the customers, but creates a good image of POs among the community. Sometimes managers, field officers and engineers adopt many unregulated practices to gain acceptance from local users. For many, these unregulated practices are a kind of business trick, or strategy. On Sandwip, a number of solar company staff have come from different districts of Bangladesh. Since they are new to this island and they need to establish a relationship with islanders, they sometimes provide extra 'perks' to build up a network with local people. As Ruhul Amin told me, he provided six solar panels to run a water pump to a commercial landlord, and four panels to a computer composition and learning shop. The 'perk' he provided was that he recorded different names for these sales: on paper, he showed ten different customers' names so that there would be no risk in him

selling the products for these kinds of purposes. He also mentions that the last time a surveyor came from IDCOL, he did not show them this area. In this way, he has built a good relationship with the customers and at the same time, he has been able to still meet his target at the end of each month.

5.4.2 Quality of the Product

The standard and quality of the product is important in any market. In the previous section, we saw that some POs have blamed non-PO solar sellers for selling poor quality products. Both the employees of IDCOL and the employees of IDCOL's POs interviewed in this study said that the IDCOL solar home system programme maintains standards on solar energy products to ensure the sustainability of the programme. These IDCOL-qualified products are the only ones permitted for use in the system. Qualifying and positioning products are major concerns for economic agents evolving within the 'economy of qualities'. According to Callon et al. (2011), the economy of qualities is based on the singularity of the goods offered to consumers. IDCOL has a dedicated Technical Standard Committee (TSC) team consisting of 6 members (chapter 4, figure 4:5), who authorise certain products to become part of the IDCOL solar home system programme. The components that are used in this programme must be approved by the TSC. For example, the Committee set up photovoltaic (PV) module specifications and certifications. To be used in IDCOL's solar home system programme, a photovoltaic module must be tested and certified from an accredited testing and certification organisation. It should have IEC (International Electrotechnical Commission)/IEEE (Institute of Electrical and Electronics Engineers)/PV GAP recommended certificates. The specifications for PV module certification are the following:

- IEC 61215: Crystalline Silicon Terrestrial PV Modules Design Qualification and Type Approval
- IEC 61646: Thin Film Silicon Terrestrial PV Modules Design Qualification and Type Approval IEC 60904-1: Photovoltaic Devices Part 1 Measurement of PV Current-Voltage Characteristics
- IEEE 1262: Recommended Practice for Qualification of Photovoltaic Modules
- PV GAP Recommended Standards are preferred.

The TSC are also responsible for approving other components such as batteries, charge controllers, compact fluorescent lamps (CFL), LED lamps and lanterns, photovoltaic (PV) modules, DC-DC converters, and appliances. When I asked IDCOL officials why the IDCOL Technical Standard Committee had chosen particular types and models of solar modules, their response was that 'These are world-recognised solar modules, and our experts decided to go

with them. Some of the respondents that I interviewed claim that sometimes the supplier POs do not maintain the standard once they get approval for their product'.

IDCOL has consequently created a mechanism where technical inspections are performed in order to maintain the quality of the product and the programme. A report in 2014 stated that IDCOL has 150 technical inspectors/engineers, based in 12 regional inspection offices (IDCOL website[36]). It also mentions that funds were originally only disbursed to POs by IDCOL after each new SHS installation had been inspected. As the program has grown substantially, inspectors are now required to inspect just 5% of newly installed SHSs before funds are disbursed. Each inspector is able to inspect around 300 randomly selected SHS installations per month, and information on inspections is entered into a central database. If an inspector determines that a SHS does not meet the technical specifications, then the responsible PO is advised to fix the problem within a certain time. An interesting piece of information was shared by a manager of a PO however, who told me that they always know when the inspection will take place because they have to arrange accommodation for then inspector. Generally, they take the inspector to a particular household to avoid possible complications. Furthermore, Wahid, a manager of another PO, told me that *"sometimes the inspector do not come to Sandwip, they send us the form and we fill it on their behalf".*

The difficulties of maintaining a large market was obvious to me on many occasions in my fieldwork. My field data also revealed that, as the programme sets larger target achievements for POs, PO suppliers are unable to meet demand *with* a supply of good quality products. Some of the leading battery companies had a series of incidents when they provided poor quality batteries, and had to withdraw a huge number of products from the market. As a result, one of the largest solar battery suppliers was banned for 6 months due to the poor-quality of their products. A similar story was also told by other respondents about charge controllers. Besides this, due to the size of the market, IDCOL is falling behind in terms of checking and monitoring the quality of the products. Some respondents believed that the quality of products and services has deteriorated since the industry has become commercialised. As one person said, "Yes, by the end of the year, IDCOL may achieve their set target, but whether the product lasts long, or the industry lasts long, is a big question".

5.4.3 Training Programs

As mentioned above, a number of interviewees asserted that the solar energy technology network and industry is suffering from a shortage of trained and skilled people in various

[36] http://idcol.org/home/solar

capacities. IDCOL provides training programs for inspectors, PO trainers and staff, customers, and technicians in order to ensure proper installation, operation and maintenance of SHSs. The training is mostly concerned with technical knowledge. There is a common perception that solar energy technology is one of the lowest maintenance renewable energy forms: once it is installed, anyone can look after it, and customers do not need to have any technical knowledge to maintain it. I had an interesting conversation with Mizan (the area manager of a PO on Sandwip) regarding the issues of staff training however:

Mizan: "*Although IDCOL arranges technical training for the staff, working in the solar sector in rural off-grid areas is not all about technical issues, it is more than technical*".

I was curious about this and asked him what he meant, realising that he was possibly referring to something that Turner (2016) argues: "as solar panels make their way to different locations, many of which have been domestic households, they become part of different modes of ordering both flows of electricity and social life" (p 8).

Mizan replied: "*To achieve success in this field, one needs to understand the mind-set of rural people, their needs, their problems. As solar company employees, we need to convince our clients. Our staff need to understand the village politics; those who are powerful, those who are not; how to solve a problem; who can be useful to spread the goodwill of our services; the best spot from which to provide our best services that encourages other people to buy solar… all these little details that IDCOL training never taught us, we all learn from our own experience, that's why I said solar is more than technical*".

The conversation that I had with Mizan was useful. He explains further: "*Sometimes, the low performance of the solar home system is not due to the poor quality of the product; sometimes the problem occurs due to non-cooperation from the neighbour*".

When asked to elaborate, Mizan replied:

"A number of times we have these complaints that the solar doesn't work well, the battery is not good, or the product needs to get changed. When our staff go, they find that there is not enough sunlight to enable the solar panel to produce enough power to charge the battery, because of a big tree by the house… sometimes the trees are owned by the household and sometimes the trees are neighbours' trees, but the tree needs to be cut or trimmed. Most times, the trees around the household are fruit trees, and the neighbour refuses to allow the tree to be cut down…. In this case you need to convince the people…these kinds of people-oriented skills are not covered in the training, but these are really important to achieve success in the field".

On the other hand, a lack of trained officials and employees on the Bangladesh Power Development Board BPDB has been a crucial issue that has had a negative impact on maintaining the quality of products in the urban solar energy transition. Due to a lack of technical knowledge about solar technology, the employees of BPDB have failed to provide an effective monitoring service to on-grid areas. After-sales services have also been adversely affected because urban-based solar technology companies and installers do not have enough manpower to provide services when the system breaks down. According to a manager of a leading battery company: *"besides market expansion, we also need to pay attention to producing skilled manpower. From the amount of energy and money that have been provided for creating a market for solar energy, I wish 10% had been given to make it a sustainable industry… so far limited progress has been made in the solar energy sector: private sectors are doing it on their own without any support from the government".*

5.4.4 Solar Energy Technology Waste

The final unintended consequence identified during fieldwork was a lack of proper guidelines for solar-related waste. According to an official of IDCOL:

"There are three types of environmental grades for a programme: red, orange and green…the solar energy programme is considered as an orange environmental programme. This means that we are not thinking about the waste or any other negative consequences of this programme"

During my fieldwork, several interviewees expressed their concern about the battery recycling practices in Bangladesh. According to Mujibur Rahman, *"IDCOL's solar home system programme sells 60-80,000 solar home system in rural areas; plus non-IDCOL sales and on-grid areas: just think about how many solar batteries go to the market every month. A good quality battery last 3-4 years, therefore every 3-4 years, how many battery recycling facilities does this sector need? Can you imagine?".*

The solar battery manufacturers that I interviewed claimed that they have recycling facilities, but due to the unregulated market, these battery recycling activities have not maintained proper practices. There is a large second-hand battery market which generally buys old batteries from customers and manually recycles the batteries without following environmental guidelines. I was told by several informants that this battery recycling takes place in the old part of Dhaka, near the Buriganga river, where small shops separate the lead from the battery case and throw the leftover acid in the river. Figure 5:9 shows Ruhul Amin, a battery recycler who is separating the lead from a used battery case.

Figure 5:9 Small battery recycling shop. Source: Author

Similarly, on Sandwip, NGO employees expressed concern over a lack of guidance as to what to do with broken solar panels and other solar equipment. Environmental issues were not their primary concern however; they were more concerned with the space that these components take up, and where they could be disposed of.

In this section, I have described a crucial but neglected aspect of the solar energy market implementation that requires greater attention from academics and policymakers. While donor organisations have been supportive in creating a sustainable market for low carbon energy to combat climate change, solar technology waste has been a neglected area that needs sustained attention.

5.5 Conclusion

This chapter has explored the process of creating a market for solar energy technology, and the complex relationships of actors within this burgeoning market. First, the chapter investigated the implementation of the solar energy market and how it has been created through a set of actors, devices and relations. Here, I traced the evolving roles of different actors, including the role of the state, international donor agencies, NGOs and private organisations as market mediators; and how different ideas, rationales and discourses have been playing vital roles in creating a market for photovoltaic solar energy technology in Bangladesh. I showed how, since the launch of RERED in 2003, Bangladesh's off-grid solar energy market has grown significantly. The initial partners of IDCOL's solar energy programme were non-profit organisations, and, later, to scale up the market for solar energy technology, private organisations were encouraged to become part of IDCOL's solar home system programme for rural development. This encouraged a number of local actors to get involved and start a new venture in this rapidly growing business.

I also demonstrated in this chapter how the initiatives that solar advocates have taken have failed to acknowledge the complex relationships of a market that is spatially constituted, and is shaped by the political and social realities of the country (Ferguson 1994). Agreeing with post-development scholarship, this chapter argues that too much attention has been given to the process of creating a market and increasing sales of solar technology products, and that insignificant attention has been given to making it a sustainable industry. A significant number of obstacles were identified and emphasised by the actors engaged in delivering solar energy. A lack of support for the local solar producers came up several times in conversation with solar energy actors. The question of the programme's sustainability is a debateable issue. While the funder believed that the solar energy programme has grown fully and does not need further financial intervention, many solar actors are in disagreement with this opinion. The success of the solar energy programme is determined by the attainment of targets for solar technology installations. However, the solar actors who work on the ground are critical about these target-based programmes, as they put the solar installer under pressure to meet the target (which often leads to an unsatisfactory level of service and poor quality of the product). Besides, solar energy programmes that are funded by international donors are not always 'free' to host governments, and often come with a combination of loans and grants that put the state under pressure to return to the donor organisations (Wamukonya, 2007). Gent (2014) raises the question of whether scarce government resources could be better allocated to other 'development' priorities.

This chapter has investigated how the markets for solar energy are made, its extensive webs of social relationships of multi-scaler solar actors, and the consequences of this process on everyday markets. The chapter has argued that the market for solar energy is not only a sociotechnical 'agencement' combining technical devices, human beings and rules (Callon, 1998); it is also an assemblage of a wide array of concerns and interests, politics, moralities and ethics (Cross, 2013). This chapter showed how the solar energy market is a highly complex, fragmented and uncoordinated space that is actively constituted through social and material relations (Castán-Broto and Baker, 2017). The chapter has cast light on the practices and politics of solar energy interventions and their impact on the energy market. In the next chapter, I present the practices and politics of solar energy interventions in off-grid areas.

Chapter Six: Living an Off-Grid Life

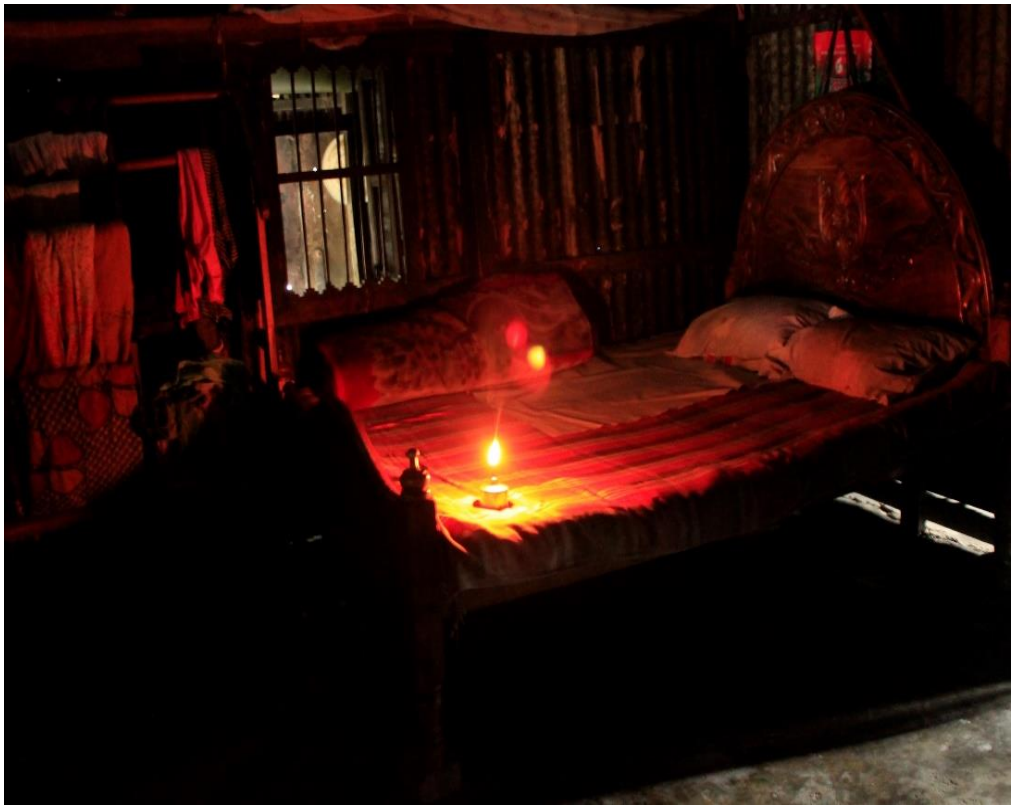


Figure 6:1 Kerosene lamps are an essential part of off-grid life

6.1 Introduction

"*Up to May 2017, about 4.12 million SHSs have been installed under the program in the remote areas where electrification through grid expansion is challenging and costly. Thus, the program has ensured supply of solar electricity to 18 million people i.e. 12% of the country's total population who previously used kerosene lamps for lighting purposes…The program has so far saved consumption of 1.14 million tons of kerosene worth USD 411 million approx. In addition, in the next 15 years the already installed 4.1 million SHS will save consumption of another 3.6 million tons of kerosene worth USD 1,300 million. Moreover, around 75,000 people are directly or indirectly involved with the program*"

Infrastructural Development Company Limited[37]

In the previous chapter we looked at the impact of solar energy technology on the energy market. In this chapter, I explore the everyday life of off-grid areas in Bangladesh which have never been connected to the national electricity grid. Following the day to day life of the people of Sandwip island, the chapter examines how those in off-grid villages live, and what it means to live with solar energy technology.

The solar energy programme in Bangladesh is considered the world's most successful solar initiative. I started this chapter with an excerpt from IDCOL's website to demonstrate how the solar energy programme is well-regarded in the developing sector that I have already referred several times in this thesis. IDCOL and solar advocates often use the success of the solar energy programme (as mentioned above) to justify further interventions that disseminate solar energy for rural development. However, in this chapter, I argue that the way the solar energy programme has been looked at and its success measured (through the number of solar technology installations and value of kerosene saved), over-shadows the everyday struggles of those living in off-grid areas with limited access to electricity. Here I emphasise that simply focusing on numbers ignores the everyday realities of those people who do not have access to electricity and their resultant needs and difficulties. According to Winther (2015) focusing on the observable and measurable loses sight of the moral economy and socially conditioned patterns of consumption. The chapter emphasises everyday life in off-grid areas because everyday life is the observable manifestation of social existence that makes social life visible (Sztompka, 2008). This research also recognises that the majority of the energy literature (See Chapter Two: Energy for development section) does not pay attention to the social, cultural

[37] http://idcol.org/home/solar

and political processes of electrification as well as low carbon energy transition. Thus, a detailed and contextually attuned analysis of the living conditions of people without access to electricity is crucial for understanding the implications of small solar energy systems in rural life. A central claim of this chapter, then, is that a stronger focus on what it means not to be connected to the national grid can offer valuable insights (Winther, 2015).

Undoubtedly, the use of quantitative methods in impact evaluations of electrification or energy transition generates important and valuable knowledge. However, this chapter argues that *qualitative* examination of the sociocultural and material context, together with an attention to the social processes surrounding electrification (Winther, 2015), can play a crucial role in understanding off-grid living. Furthermore, it argues that this perspective can be achieved by examining the everyday life of off-grid populations. The chapter draws on interviews, and participant observation with households on (off-grid) Sandwip Island associated with the introduction of two solar programmes: solar home systems and a solar mini grid (see Chapter Four).This chapter is organised as follows: the next section (6.2) contextualises everyday uncertainty on Sandwip Island, arguing that geographical location has made Sandwip a key site for NGOs and private sector actors to intervene with small-scale solar energy technologies. Section 6.3 describes various forms of light and electricity provision on Sandwip Island that the inhabitants use. Section 6.4 then turns to problematise the idea of "solar energy for all" and Section 6.5 explores what it means to live with different types of solar energy, through an attention to the everyday experiences of users of solar home systems and solar mini grids. Finally, Section 6.6 examines how solar energy users perceive solar electrification as an alternative to grid electrification.

6.2 Sandwip: Life on a Shrinking Island

Sandwip Island is located in the south-eastern part of Bangladesh, and is home to a population of more than 400,000 (Ali *et al.* 2012). The island is detached from the Chittagong mainland by a channel of approximately 75 kilometres (Khan & Huque, 2012). As Sandwip is situated in a delta, the absence of coastal defenses is slowly eroding away the island. In addition, constant fear of sea level rise and flood ingress due to cyclones makes Sandwip a land of fragile, marginal and vulnerable habitation. Life in Sandwip can be compared with other island life: for example, in its remoteness, isolation, disconnection and limited opportunities. Land is at a premium as the majority of settlements have shifted to the middle of the island due to widespread coastal erosion. Although Sandwip has a comparatively large population, with its location in the northeastern zone of the Bay of Bengal (See Figure 6:4), the national grid has bypassed Sandwip (Khan & Huque, 2012).

Figure 6:2 The passengers are waiting to board the steamer to go to Chittagong. Source Author

The islanders are dependent on mainly steamer[38] (Figure 6:2) and speed boat[39] (Figure 6:3) for connections to the mainland for physical goods. Sandwip's migration story is similar to island life the world over, except men migrate primarily to the Gulf States and women are left behind as the custodians of the family's property and children. This makes it an island inhabited primarily by women and an island dependent on remittance money. It is reported that 37 percent of the total population of Sandwip now live abroad and are sending remittances, contributing to the development of the country ('Protect Sandwip from erosion' reported in The Daily Star 23-07-2008). Although Sandwip has a large population, there is a wide debate over whether providing electricity through access to the grid for those who live in such remote and rural areas is economically feasible given the large distances and low projected levels of consumption involved (Gouvello, 2002). Moreover, due to the widely

[38] A steamer is a small water vehicle that is propelled primarily by steam power usually used on lakes and rivers. Generally, the word steamer refers to smaller, insular, steam-powered boats particularly riverboats. As using steam became more reliable, steam power became applied to larger, ocean-going vessels.

[39] Speed boats can be used only in winter season

dispersed settlements in rural areas, the operational costs involved in distributing electricity are higher compared to urban areas (Krishnaswamy, 2010).

Figure 6:3 Islanders can use boat only in winter season

Figure 6:4 Map of Sandwip island[40]

[40] Source: https://www.thebangladesh.net/upazilas-of-chittagong/sandwip-upazila.html

Thus, Sandwip exemplifies a common perception which has become dominant in energy access debates: in the places (like islands or other isolated communities) where the national grid is not available, or installation of a grid system has not been feasible so far, the extension of a centralized power grid is not regarded as a cost-effective solution (Pode, 2013). As a consequence, decentralised and small renewable technology projects are considered the best solution for solving energy access problems in remote places like Sandwip. Therefore, instead of connecting to the national grid or building up a larger infrastructure that can provide electricity for the entire island, Sandwip's geographical location has made the island a key site for decentralised and small renewable energy systems. Energy actors specialising in these types of technology have, therefore, found in Sandwip an important niche through which to expand their energy businesses. Geographical location also has an influence on the villagers' mind-sets and their imagination of possible energy futures: the island's formidable location contributes to the view that getting an electricity connection from the mainland is not possible, and that the only option available for Sandwip is either decentralised or alternative source of electricity. The following section demonstrates various forms of electricity provision in Sandwip island and how these multiple sources of light and electricity interplay in Sandwip's daily life.

6.3 Electricity provisions on Sandwip Island

In the methodology chapter (Chapter Three) I explained that the reason for choosing Sandwip as an entry point to solar energy technology for both disseminators and users was because Sandwip is a place where two types of solar energy technology have been installed: a solar home system and a solar mini grid. Before going to Sandwip, I was aware that people in Sandwip have limited access to electricity from "*Government lines":* specifically, and based on secondary literature, I knew that the government owned a 1 MW capacity power plant which supplies the main administrative areas of Sandwip. In addition, villages in the Haramia area in Sandwip are powered by the Purobi Mini Grid that supplies 291 connections combining predominantly commercial customers with a few domestic users (Khan & Huque, 2012). Thus, I was expecting to see in Sandwip these two main sources of electricity supply plus the Solar Home System: the rest of the island, I imagined, would use kerosene lamps to meet their everyday lighting needs. My fieldwork reveals, however, how people in Sandwip combine multiple sources of electricity to fulfil their need for lights and electricity. The particular combination depends on their locations and socio-economic condition, and electricity supply is not limited to only electricity from solar energy and government lines; villagers get access to electricity from generators and car batteries. Here I am separating lights and electricity as people in Sandwip continuously choose and change the sources of lights and electricity depending on performance of each system. The following section outlines the different provisions of electricity supply in Sandwip.

6.3.1 Use of Daylight

Using daylight is a common practice, not only in off-grid areas like Sandwip, but also in places where electricity is available. People in Sandwip use daylight whether they have access to solar or not. In Sandwip people told me why they need to use daylight all the time. Ameena Begum explained that "*inside our house, it is generally dark… our house is made from tin and we have very small windows and the windows are also made of tin and wood. It is very difficult to see anything inside the house. Women prefer to work outside of the house because there is not enough light inside the house. Women like me are busy finishing most of their household chores during the day time so that they can use yard space and daylight. Using daylight and space outside of the house are more convenient than working inside of the house*". Shirin Akhter, a housewife and a solar home system user explains that because of the construction and materials of villages' houses, the interiors of houses are always dark; therefore, people need to use extra light to work inside the house: "*You can only see things on top or near to the window, but you need torch light or lamp light to find anything from the cupboard or below".*

Figure 6:5 Sewing Katha using the daylight. Source: Author

In this picture (Figure 6:5), Sultana Begum is sewing a *Katha*. When I went to her house I found her sewing in her yard. Like Shirin Akhter and Ameena, Sultana Begum also wanted to avoid darkness and utilises both day light and her spacious yard. However, Sultana Begum explains that she uses daylight not only to avoid the darkness of the house but also to save solar electricity as it has a limited capacity to provide service for 4 hours: "*Though I have solar at my home, I don't use it during the day. If I use it during the day time, there will be nothing*

left for the night. I need to make sure that I make most out of day light and need to save solar for night".

Despite owning a solar home system at home, many respondents told me that they try to utilise most of the available daylight to keep the backup battery for the night (will be discussed in detalied in section 6.5). A typical solar home system is designed with four hours battery backup. Users are instructed not to use lights or television during the day; it should be saved for night-time use. Mujibur Rahman, the manager of Mati Solar, made an interesting observation: "*we always discourage our customers from using solar while it is charging: It is not wise to spend while you are earning. You need to earn and save the money and then you can spend money whenever and on whatever you want. If you don't have savings how could you enjoy spending? For solar users daytime is earning time, so users should not use the solar electricity when it is charging the battery"*. Therefore, people in Sandwip try not to use solar energy when the battery is charging during the day. In addition, many respondents informed me that to avoid using solar during the day, they try to use the daylight like Sultana Begum or Shirin Akhter.

Using daylight therefore plays a significant role in the everyday life of Sandwip Island. Irrespective of whether a household owns a solar home system or not, daylight is important in their life. While a solar home system provides four hours of back-up, nights in a tropical country entail a minimum of nine to ten hours of darkness. Therefore, solar users need to consider carefully which work they can do without electricity, usually by using other means like outside lights. Ziauddin, a businessman of Rahamatpur said *"there are a number of tasks which don't need electricity: for example, studying, cooking, and cleaning. We can do these using daylight; however, there are a few things we cannot do without solar, for example, mobile phone charging or watching television. In my home, we use solar to charge my mobile phone both in the daytime and night-time. The mobile phone is an essential thing and it consumes less electricity; therefore, we allow our family members to use solar to charge mobile phones but no other work*".

6.3.2 Government Line: Bangladesh Power Development Board Power Plant

A government-owned, diesel run power plant operates for limited hours a day in Sandwip's city center to serve the municipal offices, government officials' residences and some shops nearby. This electricity service is called the "government line" and is located in the heart of Sandwip Island i.e. the administrative and business zone of Sandwip, known as the Complex area (See Figure 6:4). It provides AC electricity from morning to 11 pm, depending on customer type. For instance, domestic users get electricity service from evening to 11 pm, whereas business and official users receive the service from morning to evening. Depending upon the type of appliance being used and fixed daily rates for each appliance, the electricity tariff ranges from 45 tk /kWh ($0.54) to 75 tk/kwh ($0.90). Such high rates are acceptable due to the unmet demand for electricity in the commercial market. In addition, small scale captive power generation from electrical generators powered by diesel fuel is found in the health centers, hotels, and other locations. Although it is considered to be the main electrical service which provides AC electricity, the Government line is considered one of the less reliable sources of electricity in Sandwip.

However, it is worth mentioning that the accommodation in which I stayed most of the time during my fieldwork in Sandwip was using the Government line. During my stay in Sandwip, it was out of order for a week. Since it was a major failure an engineer had to come from Chittagong: the repair took more than a week, and people had no idea as to when it would be fixed. It is important to mention here that the accommodation also had a combination of both Government line and a solar home system. As the Government line service stops after 11pm, domestic consumers of the Government line keep SHS as a backup. Nonetheless, geographical coverage by the Government line is limited to certain areas. In addition, it supplies for only a limited time during the night. As a consequence, households that are connected to Government line also need to have an arrangement for after 10pm or for the duration of blackouts. These alternative sources of energy include solar home systems and kerosene lamp.

6.3.3 Generators: Private & Community Based Initiatives

Diesel powered generators are another popular provision for providing electricity, and are common in Sandwip where they are used mainly for lighting. Those people who live near a bazaar and can afford to pay the bill, get connections from privately-owned generator services. According to the people that I interviewed, it is common in Sandwip for the community to take the initiative to supply electricity through communal services. As Bangladesh is a Muslim-dominated country and mosques have a vital role in the everyday life, especially in rural

communities, people run this communal service through the mosque committee. The practice for this kind of service is that the customer pays per connection basis. For instance, per light bulb costs 10-12 taka ($0.12-0.14) and mobile connections 5 taka ($0.60) per night. Having a light and mobile charging connection is very popular among those from lower socio-economic backgrounds. It saves them having the burden of a large-sized solar panel which they cannot afford. Some interviewees told me that sometimes they just get the connection for a few months if the family has any special occasions such as a wedding or family gathering. They can stop using the connection whenever they want.

"Using generators in off-grid areas is common, usually bazaars in off-grid villages are run by diesel generators. Nowadays people cannot live without electricity: there are thousands of tasks in every village that require electricity" Shafiqul Islam, a businessman of Maitbhanga, explained. Apart from bazaars, the houses of Sandwip are also powered by diesel generators. I visited a number of houses which own personal generators. On the other hand, most of the bazaars in Sandwip have generators which are operated by the bazaar committee[41]. In many cases, if two or more households are situated close to the bazaar, these households rent the connection from the nearby bazaar's generators.

In Sandwip people use generators for both domestic and commercial purposes. In bazaars, the generator is managed by either the bazaar co-operative or private individuals. On the other hand, the domestic supply is managed by the mosque committee or private owners. Although generators are used widely, reliability and safety issues can sometimes be a matter of concern in Sandwip. According to the agreement between generator owner and its customer, a generator should run between 6 pm and 10 pm, but sometimes it stops running by 8 or 9 pm without any notice. A villager in Azimpur village told me that they used to use the generator line but there was an accident the previous year when a person died due to an electric shock and so they stopped using the generator. In Sandwip lines from the generator come through very basic infrastructure. On many occasions, the setup cannot withstand strong winds, especially during the heavy monsoon period.

Kuti, a housewife based in Rahamatpur village, mentioned that previously they had generator connections from the nearby mosque, but two years previously the generators' connection broke down and a person died from an electric shock. After that, they decided not to use the generator and they started using kerosene again. "*It was very risky and we were so scared after the incident. Though the mosque committee repaired the connection, we decided not to*

[41] A Bazaar committee is a body consists of a number of business persons who look after the welfare of businesses and the local market.

use this connection anymore. It was not only our family; a number of neighboring families did not dare to use the connection after that accident". After that accident in Rahamatpur village, a number of generator users refused to use the connection; a few of them bought solar, a few bought car batteries and the rest of the households went back to kerosene.

6.3.4 Rechargeable Batteries

Similar to generators, car batteries are also a popular source of energy to run home appliances or electronic devices. The people of Sandwip use rechargeable batteries to enjoy electrical services. Usually, they use it to charge their mobiles and DVD players, sometimes for emergency lighting. These batteries are charged in bazaars and last for few days, depending on the consumption. There are a number of charging shops in local bazaars which charge a battery for 100 tk ($1.21). Rechargeable battery services are not however, that convenient as the owner needs to take the battery to the bazaar to charge: roads in rural Bangladesh are not smooth and it is inconvenient especially in the rainy season. Many informants mentioned it takes a whole day to get the battery home because of queuing traffic. In addition, most of the households in Sandwip are headed by women as their husbands live abroad and culturally it is not acceptable for women to go to the bazaar (See Chapter Seven: section 7:4). Therefore, women depend on their male relatives or neighbours to help them to get the battery charged from a charging station.

A fully charged car battery is used to charge electronic devices such as cell phones, torch lights, DVD players and sometimes light bulbs. Using a car battery for day to day light consumption is not widely practised but on special occasions like children's examinations, weddings or other celebrations car batteries are used. Jafar Ullah, a farmer from Rahamatpur explained how his family uses car batteries on different occasions. "*I cannot afford to buy solar for my household since I don't earn enough to pay for solar installation. My children have asked me several times to buy solar for their study, but solar is far beyond my capacity. We use kerosene for light and our mobiles get charged from the bazaar. Occasionally I rent car batteries for a month or two when my children have their annual examinations".*

I learned from local islanders and managers who have been working in solar energy NGOs (Partner Organisation of IDCOL SHS programme) from the preliminary stages, that the people of Sandwip have already been exposed to electricity from different sources i.e. generators, batteries etc. In the initial period of solar dissemination in Sandwip, NGO workers targeted those households who used car batteries. It was believed that people in those households which used batteries for their entertainment had a higher likelihood of buying solar as they already had exposure to TV or radio. Ahsan Habib, an employee of a leading solar home

system provider (NGO/PO) explains how they used to target prospective buyers of solar home systems:

"*It was early 2000, when we started working in Sandwip with three staff, a manager, a technician and a field officer. We used to walk through the villages and try to locate those houses who were using batteries, which meant that they were already used to television and they might consider buying this for their entertainment*".

I asked him how he knew which houses had a battery inside.

Ahsan Habib said "*we used to know this by seeing the antenna from the outside: if we saw an antenna outside of a house, it meant the house has a TV set*"

Here it is important to mention that rechargeable batteries are widely used in off-grid areas not only in Bangladesh but also other parts of the world (Turner, 2015; Jacobson 2007). With the introduction of solar energy in off-grid areas use of rechargeable car batteries has reduced. As I have discussed in this section those people who cannot afford buying solar energy, often rent car rechargeable batteries to meet their electricity need.

6.3.5 Charging Station

Charging stations provide services to those households who own neither a solar home system nor has an electricity connection from the Government line. In bazaars, several shops provide facilities to charge electronic devices, including mobile phones and other home appliances. However, solar home user Kamrul Islam observed that this was a profitable business before mobile phones became so cheap and available. Over the last decade, the use of mobile phones has increased significantly in Bangladesh due to large amounts of cheap Chinese phone sets and the sharp decrease of mobile phone tariffs. In isolated places like Sandwip Island, mobile phones have resulted in significant advances in communication. Mobile phones play a significant role in the islanders' lives for they facilitate them to communicate with those who live away from Sandwip or who are working abroad. Thus, to own a mobile is important in everyday life; I learned that people buy solar *only* to charge their mobile phones. This means that the popular argument of people buying solar for lights is being challenged by the popularity of the mobile phone; a number of respondents said that they bought solar to charge their mobile phone and that lights are only an added benefit of owning a solar system.

Previously, people used to charge their mobile phones in bazaars and it cost 5-10 tk ($.06-$.0.12). There were a number of shops which used to provide this service: *"There were many shops which had several mobile phone chargers and charged 20-50 mobile phones per*

night…It was very difficult to get your turn as everyone needed to charge their phone" Kamrul, a solar home system user explained. From the respondents' statements, it clearly emerged that this was a great help for those who did not have an electricity connection or solar at home because it allowed them to maintain communication with others. In addition to mobile phones, those stations also charge other electronic devices like DVD players, laptops and torches. However, people also told me that there were some shortcomings of using charging station facilities. Women, as I mentioned in the previous section, always need to wait for someone to take the mobile phone to the bazaar and get it charged. In the meantime, whilst the mobile phone has been taken away for charging, they are likely miss important calls which can be disappointing for both caller and receiver. Furthermore, there were also some issues reported with phones missing batteries or the bazaar owners using the mobile phone credit themselves.

Asma Khatun, a solar home system user told me that she lost her phone three times at the shop and the shop keepers were unable to ensure security. Lovely Akhter complained that her new phone battery was replaced by an old phone battery and often her phone credit was used up when she sent her phone to the charging station. Moina recounted the same problem as that of Asma and Lovely, and after a few incidents she asked her husband to send money for solar.

"*It was really frustrating to miss my husband's call. He only manages to call me once a day. I try to avoid sending the mobile phone to charge when he is due to call. But sometimes I had to as it is difficult to find someone to take the cell phone to the bazaar for charging. I lost my mobile phone twice; and losing credit during charging time is very common. Men can wait in the bazaar and look after their phone; but since our phones stay unattended, people take advantage. Sometimes if there was a long queue, shop keepers used to keep the phone overnight and I had to wait for 2/3 days to get my phone back. To avoid this hassle my husband bought solar, so that I don't need to go to the bazaar, or depend on others to take my phone to the bazaar; this way we don't miss each other's calls*".

Accepting the inconvenience, the people of Sandwip believe that charging facilities play a crucial role for villagers who cannot afford to buy a solar home system. It is helpful to those families who cannot afford to rent a generator connection throughout the year. In the Figure 6:6 we can see family members of this household watching a film from a rechargeable DVD player. This household did not have solar electricity; this small rechargeable DVD player was also charged from the bazaar. This family showed me that they have a number of small electronic devices at their house, including two mobile phones, one torch light and a DVD player and all of these get charged from nearby market's generators.

Figure 6:6 A DC DVD player which was charged from Bazaar for twenty taka. Source: Author

Table 6:1 Sources of light and electricity

Sources	Provider	Duration	Cost (tk)	Appliances
Kerosene Lamp	Retail buy	N/A	Vary	No electric appliances
BPDB	State	4-5 hours	3-4 tk per unit	Lights, fans, water pump
Generator	Private/ local	4-5 hours	5-70 per appliance per night	For domestic lights only For commercial varies on the nature of business
Car Batteries	Private	4 hours	20 tk per charge	Use for TV
Solar home system	Private/ NGO 7 NGOs	4 hours	16-25 tk per unit	Light, mobile phone charging, TV
	Local entrepreneurs			
Solar Mini grid	Private	5 hours	32 tk per unit	Most of the electronic appliances, but the customers have a limit to how much they can consume, or they need to declare their consumption of devices before their application for connection

Furthermore, solar energy transition in off-grid areas in Bangladesh has brought changed and shaped energy use and practices. A wide range of literature demonstrates the benefits of solar energy and how it shapes rural life (Mondal & Klein, 2011; Asaduzzaman et al., 2013; Wamukonya, 2007). The transition of solar energy in off-grid areas helped reduce the dependency of the villagers from the kerosene lamp, car battery, charging station and generator. Table 6:1 demonstrates various forms of light and electricity which are used on Sandwip island. Depending on location and economic ability (see Section 6.4), a household chooses to access energy provisions from the above listed sources. While kerosene lamps are widely used across the island, the rest of the energy provision access depends on affordability and location. For example, the Government line and Purobi mini grid are only

available in Complex and Haramia areas (See Figure: 6:4) as these services have limited transmission capacity, whereas solar home systems are widely used across the island as solar home systems are a small and portable technology.

6.4 Solar Energy is not for all

This section explores in detail the target customers of solar energy NGOs and business organisations and how people in Sandwip get access to solar electricity. In Chapters One and Four I discussed how the global agenda "Sustainable Energy for All" and the national agenda "Electricity for all by 2021" influence the solar energy transition in Bangladesh. During my fieldwork in Sandwip, the interviews that I had with local NGOs and people in Sandwip revealed that there are various meanings and layers to this 'All' among local people. It reminds me of what Kumar (2015) argues in his paper that ''All' at the global level may be seen as a homogeneous group of people who are characterised only by their lack of electricity access. Kumar (2015, 16) emphasises in his paper "we need to disentangle the 'all'. We must deconstruct the 'all' and go down to the most micro – individual – scale to find suitable definitions of 'electricity access".

I began my conversations with the islanders (those I interviewed, discussed in Chapter Three) by asking 'who are the users of solar home systems in Sandwip?' By using an open term 'who', I obtained a number of answers involving users' social-economic backgrounds, types of users, users' needs, different utilities, changes of users and different sources of electricity and lights and so on. A common answer to my question was 'those who can afford this expensive technology'. In Chapters Four and Five I demonstrated how solar energy technology in Bangladesh has been brought to rural people through a programme called the Solar Home System Programme which is funded by the World Bank through IDCOL's selected partner organisations. As solar technology is expensive and beyond the reach of many rural people, this programme has brought with it a system of microfinance systems (Rankin, 2002) which allows users to pay in small instalments for up to three years after the date of purchase. I explained in Chapter Five how this financial mechanism has been adapted by the IDCOL solar home system programme and donor organisations have been supporting a credit-based model. There is no doubt that this initiative is helping to make this expensive technology accessible and affordable to many rural people. However, in Sandwip I found that solar technology is still beyond the reach of many islanders who remain dependent on kerosene for lighting.

I have encountered many islanders who are not using the solar home system as this technology is still beyond their affordability, a finding that echoes with other research on solar

energy access (see, for example, Jacobson (2007) in the Kenyan context). Rather than only interviewing those who use solar home systems, I was also interested in those who are *not* using solar home systems, and what the reasons behind this are. A common response to this question was similarly 'the people who can't afford it'. I therefore I kept pushing this issue by asking 'who are these people?' Exploring the lives of non-solar users provided different aspects of rural life and their everyday reality. For example, Sandwip islanders explained how day labourers who earn money on a daily basis and do not have permanent jobs or who have seasonal or contractual jobs, could not afford the solar home system. As they earn money on a daily basis, they are not able to pay the down payment which is 10% or 20% of the total solar home system package. In addition, most of the solar companies include one or two installment deposits in case a customer fails to pay an instalment in future. This advance installment helps the field officers to be secure if anyone fails to pay an installment. On the other hand, even if a customer manages to get their down payment arranged, paying monthly istallments may still be beyond their means.

Figure 6:7 Interior of a solar home system user in Rahmatpur. Source: Author

If we look at carefully at the Figure 6:7 we can get a sense of the economic condition of this household. In Sandwip, the majority of the solar energy users are relevantly well off, as either the main earner of that house has a fixed monthly from a stable employment in Sandwip, or through work as a migrant worker aboard. The decorative furniture of this picture (Figure 6:7) clearly demonstrates the affordability of this house. On the right hand side, there is a cupboard

which is full of crockery and electronic devices brought by the son of this house who live in Dubai. However, the adaption of solar technology in off-grid areas is yet to reach to the lower socio-economic parts of the population which has also found in other geographical context in other research (See Jacobson 2007; Gent, 2014).

In Sandwip I found a number of households who could not afford the solar home system and are using kerosene. For example, I was conducting an interview in one household in Rahamatpur, in the eastern part of Sandwip. When I was nearly finished, a few neighbours joined us. I tried to get a conversation with them going, so that, should they allow, I could come back later and interview them as well (this being an effective method to recruit research participants (Chapter Three). While I was asking them who uses solar energy, I found that only one elderly man's family was not using it. I observed that he did not respond when I asked this question and that it was clear he was uncomfortable with the others were telling me that his household did not have any solar energy technology. One of the group members asked him why he was feeling embarrassed and why he was not telling me that he does not have solar energy. I understood that the topic of solar energy ownership was a sensitive subject, having also been informed that having solar energy was a 'symbol of status'. This is reminiscent of Urmee & Harris's (2011) study where 82% of their respondents informed them that their social status had gone up as a result of installed SHS in their residences. I thus stopped the conversation and obtained the elderly man's permission to visit his family later, on my own.

When I visited the elderly man (Abdus Sattar) for the second time, he was more open and shared his views and opinions about having solar energy. According to him:

Abdus Sattar "*Solar electricity is very important in our life; it gives us lights. But not everybody has can afford it. There are many poor people like me in Sandwip who can't afford solar energy, but it doesn't mean that we don't need it or want it. In this Bari*[42] *out of 10 ghars (households), I am the only one who cannot afford solar energy as I am extremely poor and live hand to mouth. It feels bad when I see that only my house is in dark and others have lights*".

Abdus Sattar continued *"I am a day labourer; I earn 150-300 ($1.81-$ 3.62) taka per day which is neither fixed nor regular. For me it is not possible to save or keep 800-1200 taka per month to pay the solar energy payment. At this moment, we (our family) use a kerosene lamp; our*

[42] *Bari*- homestead or compound consisting of a cluster of homes that are directly related to each other or in same kinship structure, generally around a common courtyard

kerosene cost stays in between 500 & 700 ($6.03-$8.44) taka per month which is quite close to a small solar home system's instalment. Still, I am hesitating to buy solar energy".

Raihana "*But why? If you say your kerosene cost and small sized solar costs are relatively close? Why are you not buying a solar for your household*"?

Abdus Sattar "*You need to understand it is a big burden for me and my family, no matter how small the solar I buy is. First of all, if I buy two solar light bulbs, it won't be enough for a big family like us, we still need to spend money for kerosene. Moreover, I can buy a small amount of kerosene for a day or few days as I earn money on a per day basis. I can spend money for kerosene on the basis of my income. But for solar no matter we use it or not. But with kerosene, I am not bound to pay 1000 taka ($12.05) per month to light up my house, if I don't have money; I simply stop lighting up my house".*

Raihana *"So you are saying you have more control over your use and spending. Right?"*

Abdus Sattar "*Yes yes…Sometimes, if we run out of kerosene completely I can buy kerosene on credit from a nearby bazaar or I can lend a kotta kerosene from my neighbour. Once I have money I can return it to them. But once you are committed to buying a solar, you are in a trap, it is your every month's burden for three years. And who knows if I can earn that much money for next three years, who knows if I can save money end of every month? This is the reason why I decided not to buy a solar home system for my household".*

A number of pertinent observations emerge from this conversation. First, it is clear that although IDCOL's solar home system programme is trying to bring solar technology to the rural people who cannot afford it, it is still beyond many people's reach. That means that the SHS programme caters for a certain group of customers, but not everyone. When I asked the staff NGOs who sell solar home system in Sandwip what the capacity ranges of solar home systems that they sell, are, I was informed that previously they used to sell 20 watt -120 watt solar home systems, but now many companies have stopped selling 20 watts since as is it less profitable. According to the manager of Mati Solar, a leading solar NGO/PO *"from the head office we are told to encourage customers to buy bigger solar homes system' because spending time and staff to sell small solar home, systems is not cost-effective, whereas a large size solar home system brings more money for the business".* This form of market orientated profit-making business are less interested in selling small solar home systems which are more affordable for many households; they are more interested in making a large profit margin. Thus, a large profit-making mind-set excludes a large population of poor people who do not have the ability to buy even a small capacity solar home system.

According to a recent ADB report (2016) 31.5 % of the Bangladeshi population live below the national poverty line[43]. In rural areas, an estimated 35 % of the population lives below the poverty line and 29 % of those in rural areas are considered moderately poor, In order to understand whether those people who do not have stable, uninterrupted income can have access to solar home system programmes. I asked Abbus Sattar if he could borrow money from micro-finance organisations to buy a solar home system. From our conversation, it appeared that he had never thought about this matter. As he pointed out, even if he did obtain money from a microfinance organisation, it would still be a loan, and having solar energy at home would not help to increase his family income (See Chapter Seven).

As part of my research, I aimed to understand if the network of solar technology is also directly linked with micro-financed companies. From my Sandwip field experience, it can be said that people do not consider buying SHS using money from micro-credit loans. I asked Professor Pasha, a retired professor of Sandwip College, now working as a manager of a micro-finance organisation, whether his organisation provides money to buy solar home systems. He replied that usually the idea of providing micro-credit loans is for people to be able to improve their lives. Theoretically, the idea of micro-credit is to develop and improve poorer peoples' economic conditions through income generative activities. So far, Professor Pasha's organisation has provided loans for going abroad, starting a business, investing in poultry farm of fish hatcheries. Sometimes people take loans to bear the expenses of a daughter's marriage ceremony or dowry but they do not for buying a solar home system for domestic consumption. According to Professor Pasha, people can buy solar technology after receiving the money, but officially they do not provide money to buying solar. One member of staff from another solar energy NGO mentioned: "*our work starts where micro finance NGOs stop, micro credit works with the extremely poor; our target group is those who have stable income and have enough money to spend after buying food."*

The conversations with Abbus Sattar, Professor Pasha and NGOs employees show that the current mechanism has failed to ensure energy access to everyone in Sandwip Island and solar energy that is not for all. It therefore challenges the global initiative that has been agreed by international donor organisations to ensure energy access for all by 2030. My intensive engagement with the villagers in Sandwip helped me to see beyond numbers of only successful solar home system installation, and to engage with the social processes and implications of having access to solar electricity. My interactions with Abbus Sattar confirmed

[43] Asian Development Bank. (n.d.). *Poverty in Bangladesh*. from https://www.adb.org/countries/bangladesh/poverty

the social value of having access to solar energy and social equality through this energy access. Further, the conversation with Prof. Pasha challenges the popular claim that often is made by international donor organisations and NGOs that solar energy technology helps the rural poor to increase their income. During my stay in Sandwip, I learnt that the solar home system has only a limited contribution toward income generative work in rural Sandwip. This sentiment is also shared by Rahman and Ahmad (2013) as they claim that SHS's contribution to income generation and employment is not significant. This argument will be explored further in Chapter Seven.

The following section investigates how people in Sandwip integrate solar energy technology into their everyday life? It will interrogate further what it means to live with solar energy, focusing on both the solar home system and solar mini grid technology.

6.5 Living with Solar Energy: Everyday of Solar Energy Users

This section focuses on how people live with solar energy technology. As I mentioned this before, in Sandwip there are two types of solar energy technology used: solar home system and solar mini grid (discussed in Chapter Four). Table 6:1 also shows the tariff of these energy provisions. According to the respondents that I spoke to during my fieldwork, solar home systems and solar mini grids are accessed by the rural middle class who have a stable income to pay the down payment for a solar mini grid and credit for the solar home system. In contrast, using car batteries for lighting is more seasonal and used for special occasions or school examination time. According to the manager of R Solar: *"solar is a credit business, we need to make sure that we will get our money back, those people who do not have steady monthly income are not our target customer".* This sentiment is common among solar NGOs in Sandwip; not everyone can afford to have access to solar electricity, and therefore a large of part of the population have always been priced out of this solar business target range.

The following section demonstrates how different forms of solar electricity materialise in different spaces and through different devices, and how these then constitute everyday life in markedly different ways.

6.5.1 Solar Home Systems (SHS) in Sandwip

The Solar Home System (SHS) is the most widely used energy service and so far, approximately 20,900 SHS units have been installed under IDCOL's solar home system programme in Sandwip Island (Hasan et al., 2012). A typical solar home system consists of four main components: a solar panel, a battery, an inverter and a structure (Figure 6:8). A few other accompanying components come with a solar home system package. These are: a charge controller, wires, and sockets. Based on the size, a number of home appliances can also be added. However, it is important to note that no other electronic appliance will be accepted by the solar home system provider i.e. IDCOL's Partner Organisations (POs) except for a fixed number of lights, a mobile phone charger, or a black and white television.

Figure 6:8 Components of a typical solar home system: Source: Author

There are several packages of the SHS on offer to clients for installation. A household or any other entity purchasing the system from an NGO (Partner Organisation of IDCOL) may choose from packages ranging from 10 to 130 Watt-peak (Wp). One of the most popular models has been the 50/55 Wp SHS (ref), which can be used for lighting, charging of electrical appliances like mobile phones, charger lights, etc., as well as for running a radio and a black and white TV. In terms of capacity, the most commonly used sizes are 40, 50 and 65 Wp which are assumed to be more affordable compared to other big sizes (S. M. Rahman & Ahmad, 2013). The following table provides an indication of the price and capacity of different solar home

systems packages that are sold in off-grid areas under IDCOL Solar home system programme by the Partner Originations (POs).

Table 6:2 Sizes of SHS and packages of components[44]

Capacity	Home appliances that can be used	Operating Hours	Other components	Total price
20 Wp	Two lights, each 6 W capacity Mobile charger 1	4-5 Hours	One 20 Wp solar panel, One 30 Ah industrial battery	11,560 tk US $170
40 Wp	Three lights, each 6 W capacity 14″ Black & White Tv 1 Mobile charger 1	4-5 Hours	One 40 Wp solar panel, One 55 Ah industrial battery	22, 500 tk US $ 328
50 Wp	Four lights, each 6 W capacity 17″ Black & White Tv 1 Mobile charger 1	4-5 Hours	One 50 Wp solar panel, One 80 Ah industrial battery	28,000 tk US $ 408
65 Wp	Six lights, each 6 W capacity Black & White Tv 1 Mobile charger 1	4-5 Hours	One 65 Wp solar panel, One 100 Ah industrial battery	34,00 tk US $ 496
85 Wp	Seven lights, each 6 W capacity Black & White Tv 1 Mobile charger 1	4-5 Hours	One 85 Wp solar panel, One 130 Ah industrial battery	42500 tk US $ 620
120 Wp	10 lights, each 6 Wp capacity Black & White Tv 1 Mobile charger 1	4-5 Hours	Two 120 Wp solar panel, One 100 Ah industrial battery	65,000 tk US $ 948
130 Wp	11 lights, each 6 W capacity Black & White Tv 1 Mobile charger 1	4-5 Hours	One 130 Wp solar panel, Two 100 Ah industrial battery	68,000 tk US $ 991

From the above table it is clear that the capacity of a small solar home system is limited as it can only run limited number of home appliances. It is important to note that IDCOL has a strict rule that the household is not allowed to use devices with its solar home system technology that are not part of IDCOL guideline. For example, a 40 wp Solar home system is allowed to

[44] Sizes of SHS and packages of components (as of January 2009) based on Grameen Shakti price list (2009). This price list is applicable for rural areas only. For every package, a charge controller and other accessories are included. The exchange rate is from the Bangladesh Bureau of Statistics 2009. US$1 was equivalent to 68.60 taka in 2007–2008. This table is adapted from (Komatsu et al 2013) with a combination of IDCOL's representation in 2015 from IDCOL's website.

have three lights (each of 6W capacity), one 14″ black and white TV, and one mobile phone charging cable. Apart from these, no other home appliance is permitted to connect with the system.

Buying a solar home system is not straightforward (Gent, 2014). For example, after a careful calculation of needs, a household decides how many light bulbs' worth of solar they buy. Further, knowing how many light bulbs they need may not be an easy task or straightforward for many families. The first hurdle of buying solar is the down payment along with two installments. As solar is an expensive technology, many households need to calculate carefully the minimum number of light bulbs they need to be able to manage their life. Abdul Hadi and his wife explain how they calculated the need and size of their solar home system:

"*While we were thinking of buying solar, we asked ourselves- what is the main purpose of buying solar, which was the children's study. Then we discussed what else is important…then we thought we would need light for our main bedroom, a light between the kitchen and dining space and another light for children's room. We did not count the toilet and store room since we don't use them all the time, when we need we will use a lamp".*

This is an example of how a prospective solar home system user starts negotiating from the very beginning of their purchase. This negotiation continues and is shaped spatiality of family dynamic, age, gender, class, religion.

Afroza explains how their family struck a balance between their needs and their financial capacities by making structural changes to the house. Afroza is a housewife and her husband works in a school. They bought solar for their children's study. They have a big house consisting of five rooms, but they can only afford a four light bulbs system. Thus Afroza's family decided to reorganise their bedrooms. The brightest light was given to the living room where the children use the space to study; the second light was given to their bed room. The third and fourth lights were set up between two bedrooms and dining space and kitchen:

"*we came up with this idea from one of our relatives, they suggested us to set a light between two rooms and now you can see*".

Afroza took me inside of the house and showed me how they had arranged their lighting, in particular she showed me her children's rooms, one room for sons and one room for daughters. I noticed that they had cut away a metre of the partition between the rooms and placed a light bulb between the two rooms. Similarly, they had set up a light between the kitchen and dining space to cover both rooms. According to Afroza,

"*as we can't afford more than these, we decided to bring change in the structure of our house. Actually, our bedroom was one of my children's current rooms, but we decided to keep their room beside and we moved to another side of the house*".

I therefore asked her why they moved their bedroom. Afroza explained:

"*all of my children go to school, they have pretty much the same timetable. So we decided to arrange a light for them as they go to bed earlier than us. Sometimes my husband needs to work until late night when he marks examination papers; therefore we thought that sharing lights with us will be difficult for children's sleeping"*.

Figure 6:9 Sharing a light between rooms. Source: Author

This conversation reveals the socio-economic process of having access of solar electricity in off-grid life. It discloses the struggle of making a balance between energy needs and affordability. While Hadi explains how they have set priority among their family needs, Afroza explains the structural adjustments undertaken within the limited resources and capacity of a solar home system. This sentiment is common among the solar energy users that I interviewed in Sandwip. I have seen similar kind of practices where rooms share lights (Figure 6:9) as having a solar home system that can light up the whole household is not affordable for the majority of the households I visited during my fieldwork.

6.5.2 Purobi Solar Mini Grid

The last and the most recent addition in Sandwip Islanders' off-grid life is a solar mini grid. PUROBI Green Energy Limited (PGEL), a private company based in Sandwip Island, was the first solar mini grid project in Bangladesh. PGEL is a consortium of four NGOs who work in the micro-finance and solar energy sectors and the power plant has been in operation since September 29, 2010. Purobi mini grid plant is a 100 kW capacity project accompanied by a 40 kW backup Diesel generator and is a combined operation of several sub-systems. According to Khan and Huque (2012) Solar PV modules are the main power generation systems that are operational during the daytime. For a nominal power of 64.8 kW, the PV modules are connected to 6 grid tied to 11 kW inverters, which converts from DC to AC power at 220V supply directly to the mini-grid distribution line at all times. The unused portion of the generated power is stored in batteries through 12 bidirectional inverters called 'Sunny Islands' which are distributed in 4 clusters (See Figure 6:10).

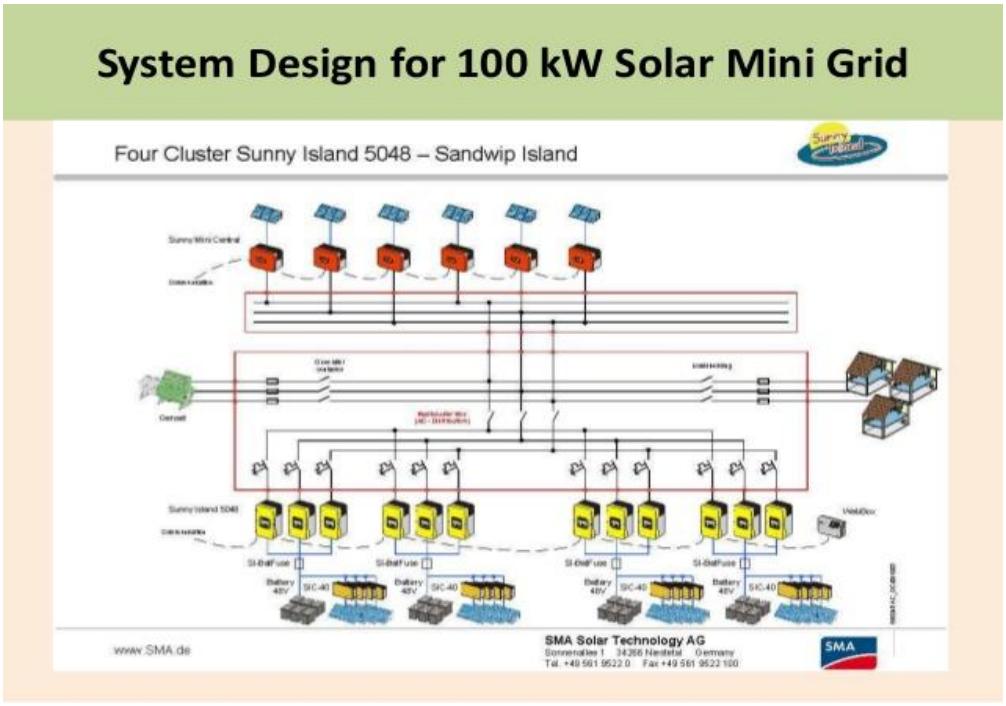


Figure 6:10 System design of Purobi Mini Grid (Khan & Huque, 2012)

The way that this plant works during daytime means an additional 40 kW PV is generated and stored into the same battery bank through DC battery chargers. When solar power is not available, mainly during evening hours, the plant uses power from this battery bank. According to the manager of Purobi mini grid, the project provides services to 288 electricity connections

with a combination of 55 households; the rest are commercial and organizations including schools, mosques police stations, together with a private hospital.

Table 6:3 Energy Consumption of PGEL Consumer Categories

Consumer class	Consumer		Energy	
	Nos	%	Total kWh/ Monthly	%
Large Consumer (100 kWh)	22	8%	5,038	44%
Medium Consumer (41-100 kWh)	49	17%	3,087	27%
Small Consumer (1-41 kWh)	217	75%	3255	29%
Total consumer	288	100%	11,380	100%

Source: Khan et al., 2016

Similarly to the generator and Government line, the Purobi mini grid provides electricity for a fixed number of hours. To receive a connection from Purobi Mini Grid, each consumer paid Taka 5000 as a connection fee and a flat rate of Taka 32 per unit is charged for each kWh used (per kilowatt hour; US 41 cents per unit) has been fixed by the owners of the mini grid. The biggest consumers of the power plant's electricity are the Muchapur Union Police Station (Table 6:4), which pays around Tk 12,000 to Tk 13,000 (US$153 to $165) per month. I further learnt that there was a conflict of interest between the bazaar committee of Enam Nahar and the owner of the mini grid when the mini grid was finished and ready to give access to the villagers. Prior to the establishment of Purobi mini-grid, Enam Nahar bazaar was electrified by generator owned by the bazaar committee. Thus, electricity supply from Purobi mini grid would put an end to the generator electricity supply business for the bazaar committee.

Initially, the owner of Purobi mini grid proposed to set the electricity tariff at 40 Taka per unit ($0.47). This was unexpected for the people of Sandwip as they did not expect to pay a tariff that was 10-12 times higher than a national grid connection. The people of Sandwip were very disappointed and initially refused to receive electricity access to Purobi mini grid. According to the secretary of Enam Nahar bazaar committee: *"we were shocked when we learned that they are planning to sell electricity for to 40 taka unit. We had a number of meetings and negotiations and finally, we came to the conclusion to sell for 32 taka per unit ($0.38), which is still a very high rate".* I asked one of the owners of the Purobi Mini Grid why the price of the mini grid electricity is expensive. The owner informed me that the durability and reliability of service were the main goal of this project. Hence the hardware was selected with superior

performance and quality assurance to maximize the use of solar power. The plant includes Solar Modules of KYOCERA, Battery from Hoppecke, Germany, and Inverters from SMA Solar Technology of Germany (Figure 6:11).

Figure 6:11 Inside Purobi mini grid power station

Nurul Alam, a leading member within the Enam Nahar bazaar committee told me they did not have any other option but to accept this offer as they did not have many options to choose from. According to Nurul Alam, "*mini grid owners were taking advantage of Sandwip's Islanders' helplessness and a life lived in uncertainty. It is so unfair that we pay a price 6 to 8 times higher compared to rest of the country for a limited period. We don't have the ability to choose or say anything regarding the unfair tariff, timing, services".*

I asked Nurul Alam why the bazaar committee accepted the tariff, to which he replied: *"the bazaar committee had to accept it when individual businessmen calculated the cost between generator electricity and mini grid and found that mini grid is cheaper than bazaar committee service".*

This echoes what Bakker (2001) argues in the context of water access and how, with the introduction of privatised services, the notion that all citizens should have access to a certain amount of services regardless of their ability to pay is replaced by the concept that consumers

should have access to services based upon their *willingness* to pay. Electricity from generator costs significantly more than electricity from the National Grid. Therefore, many who live on Sandwip believe that because of the negligence of the state, *"the private organisations are taking advantage and treating electricity business as profit making site" said Nurual* Alam, member of bazaar committee.

Figure 6:12 Bright light connection from mini grid. Source: Author

Khan et al., (2016) note that in Sandwip large, often commercial consumers average 205 kwh and pay around 7008 tk ($84.46), medium consumer consume 59 kwh pay on average 2,102 ($25.33) tk and small customer use around 12.23 and on average monthly pay 531 tk ($6.40). After initial disagreement, finally the tariff was set for 32 taka ($0.38) per unit and a number of commercial activities were developed in the Haramia area based on the Purobi mini grid (Figure 6:2). Purobi mini grid has gained trust as a reliable electricity supply compared to the Government line, and it offers more freedom to use various electric appliances than the solar home system technology. The most attractive facility that Purobi mini grid offers is AC electricity, as this allows people to enjoy all electronic devices. Komola Rani, a housewife living in Haramia area said, *"with solar you can only buy special types of TV or lights, but with Purobi you can buy any electronics from Dhaka or Chittagong, it has more freedom, you can choose your items from a wide collection".* Like Komola Rani, other mini grid users also admitted that mini grid technology offers freedom to choose and buy electronics items from shops because AC devices are widely used in all over the country. For DC devices options

are limited and not many shops sell DC electronic devices. Lately due to the expansion of the solar energy market a number of shops sell DC electronics devices in Sundarban market (Chapter five). However, this is still limited compared to AC electronic devices in the market.

Mini grid users that I interviewed often described this form of electricity as “electricity like city” or “facility like city” because of its capacity to power bright lights (Figure 6:12). There is a common saying that because mini grid technology allows the user to use “normal” appliances (i.e. AC appliances) it makes life as easy as the city. By “normal” the mini grid users mean they do not need to buy a home appliance that is especially made for DC, thus they can have access to a variety of options. In this regard, the most important home appliances people with access to AC supply can buy is a fan, as the IDCOL solar home system package does not allow customers to use a fan in order to protect the battery’s longevity.

Initially, the owners of the mini grid thought they would allocate 100w per customer. However, when it started operating, they realised that customers were not satisfied with 100w, and so decided to increase by 110/120w to domestic customers and 500w to commercial customers. According to Faruk Hossain, an employee of the mini grid *‘even with increased allocation, the customers were not happy’.* He further commented that a number of heavy load electricity appliances have been inserted into local shops, for instance, freezers, photocopy machines, and compiler-printers. He was therefore anxious about how the mini grid would cope with this heavy load in the peak of summer. Faruk Hossain complained that customers will usually extend the wire once they have a connection, which has a negative impact on generation and consumption. Usually he encourages customers to use heavy load electronic devices during the daytime, so that the load can be supplied directly from the panel rather than batteries. However, he noticed that customers are unlikely to follow these instructions: they extend wires and use more electricity than requested. Table 6:4 explains the loads non-domestic users receive from Purobi mini grid. The table also demonstrates how much excess loads need to give the mentioned clients what the authority expected.

Table 6:4 Consumers connected in the first month

Consumer Name	Estimated Load (Watt)
Sandwip Police Station	3200
Rupali Cooperative (Micro finance organisation)	950
Taj Hotel (Hotel)	1380
Fashion plus (Shop)	490
Popular Feed (Poultry Farm)	305
Rocky Dew Store (Convenience Store)	310
Digital Clinic (Medical centre)	1080
BNPS (NGO)	670

Source: Khan and Huque, 2012

In addition, several further limitations were identified by the users that I spoke with in Sandwip. The mini grid has a capacity to provide 1 kW electricity and currently it is providing services to 1 km of Enam Nahar/Haramia area. Therefore, this city-like electricity facility is available for only the limited area of Haramia covered by this service. Furthermore, like the Government line, it also provides service until 10pm. Many household consumers argue that 10 pm might be fine for business or commercial use, but for domestic use it is not enough. Lighting the bazaar also has effects on domestic life. It changes domestic scheduling: for example, it pushes the evening meal further back into the evening, as women wait for men to come back from the bazaar to serve the meal. The women whose households are connected with Purobi mini grid explained to me their dissatisfaction with how the timing of Purobi is not suitable for women's domestic work.

Lotifa Begum complained that her husband comes from the bazaar when he closes his shop, and when he is back, she needs lights to serve dinner. However, Purobi stops supplying electricity as soon as the bazaar closes. Similarly, Komola Rani was dissatisfied that she never enjoys daily television series and can never finish a movie as after 10 pm she will not able to see it. Thus, domestic users have several times requested the Purobi mini grid authority to arrange different times for domestic customers and bazar customers. But according to Faruk, an employee of Purobi mini grid, it is not possible to provide electricity at different times as there is no provision for this in the system. This conversation brings to the fore a frequent and important criticism from post-development scholars make - "homogenisation" of needs of the Global South (Ziai, 2007).

Esteva (1992: 7) argues on that day, two billion people became underdeveloped . . . from that time on, they ceased being what they were, in all their diversity, and were transmogrified into an inverted mirror of other's reality: a mirror that belittles them and sends them to the end of the queue, a mirror that defines their identity, which is really that of a heterogeneous and diverse majority, simply in the terms of a homogenizing and narrow minority. The way development advocates see poor and their needs in the Global South is often has a homogeneous group without any recognition that there are multiple social categories such as class, gender, caste, religion. Feminist scholars argue that even within a household men and women have very different needs that are shaped by social, cultural space of a geographical location (Kabeer, 2005)

In this specific context of energy access and homogenisation of people's needs, 'time' and 'season' are other factors that bring variation in people's need in Sandwip. Figure 6:13 presents the daily load profile of Purobi mini grid. From this figure it is clear that demand for electricity follows a steady pattern: between 10 am and 6 pm, in the daytime electricity demand reaches up to 20 kW, whereas the peak hours between 7-10pm the demand reaches up to 40 kW which is the maximum capacity of the Purobi mini grid power plant. According to Khan and Huque (2012) the overall trend in energy consumption has a cyclical nature which follows the seasonal demand for energy. Winter months (i.e. November to January) have a lower peak energy demand than in summer because in winter people do not electric fan. However, this timing coincides with the onset of overcast days from the monsoon. As a result, the mini grid needs to be prepared to meet the increasing demand for electricity in June through September in spite of the decreasing generation from solar in this period of the year. In peak electricity season (April to October), the maximum consumption of energy is more than 13,000 kWh compared to a little over half this (7,500 kWh per month) in the winter months of November to March. These pressures can expose the fragility of the system: in summer 2011, for example, excessive pressure on the mini grid created a disruption to power generation and the system was out of work for three days.

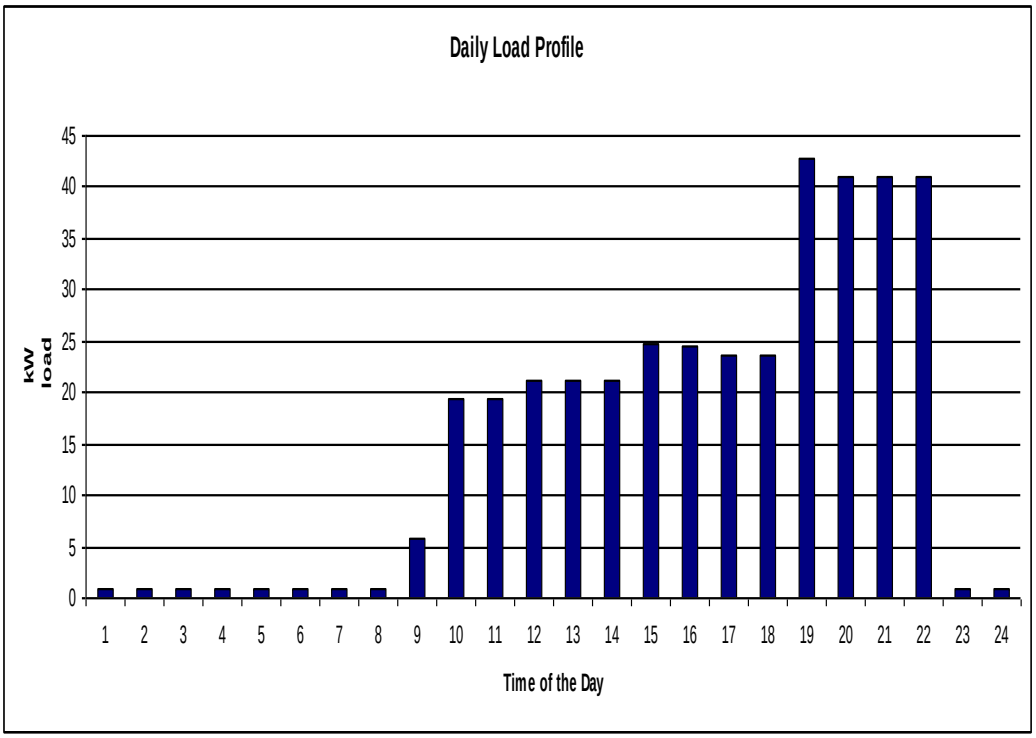


Figure 6:13 Daily load profile of Purobi mini grid. Source: Khan and Huque, 2012

Faruk, an employee of Purobi mini grid shared a typical example of how customers can easily avoid an inevitable situation, such as a failure of the system or shortage of electricity supply during peak hours. For instance, water pumps consume a high volume of electricity and therefore, people are encouraged to use water pumps during the day. One hospital was not following the instructions and was turning on the water pump when needed, which has always a negative impact on mini grid electricity storage and supply. While Faruk's frustration and concern that customers are not following the instructions are understandable, a perhaps more vital question here is how could an organisation like a hospital negotiate with this when their services are very important for people's lives? I also talked to the authority of the hospital and they explained that they do have a backup generator to face unexpected failures, but they cannot always use that since it is expensive to run. Jan-e-Alam, a member of the hospital management asked, *"what's the point of having this service if we cannot use it when it is needed?"*

This sentiment was observed several times during my fieldwork. Like solar home system technology, solar mini grid users also need to discipline themselves on how to use the electricity. As Faruk suggested, easy ways for individuals to avoid problems can become a significant problems for mini grid users overall. Faruk further told me that after a recent experience of power disruption he started checking whether his customers were extending wires and using more electricity than they were allocated. The tension between the mini grid authority and users highlights the way certain norms of behaviour around different electricity

supply have to emerge for them to function as designed. The conversation between the mini grid supplier and mini grid users demonstrates the need for collective norms of behaviour and social practice to maintain a steady electricity supply.

6.6 Solar energy is not electricity

"*This solar, solar, we don't have electricity*"- Parveen Akhter, a housewife

"*We don't have electricity like city, we are not lucky like you*[45]"- Runa Laila, a housewife

"*This is our misery that we cannot provide proper electricity to our children*"- Nurul Islam, a shop keeper

The diffusion of solar energy in off-grid areas is part of the Electricity for all by 2021 policy (discussed in Chapter Four). Nonetheless, it is important to note that people in Sandwip do not perceive having access to solar energy as being the same as having access to electricity. In almost every single interview in Sandwip, villagers recited a long list of problems of not having "proper electricity". A number of times villagers reminded me or corrected me when I referred to "solar energy" as "electricity" by saying "*we don't have electricity, this is just solar".* The people that I interviewed in Sandwip talked a great deal of their misfortune in not having "electricity" on the island.

I tried to understand what the villagers meant when they referred to solar as not being proper electricity, so explored what quality is required for electricity provision to be considered as "proper electricity".

A solar engineer who works in one NGO in Sandwip believes "*Sandwip would have been more developed if we had electricity".* Nurul Islam told me his frustration at not having electricity in Sandwip,

"I lived in Abu Dhabi for 15 years…there I used to have everything: light, fan for 24 hours, tv, cassette players, VCR (video cassette recorder), VCP (video cassette player). I have always wanted my family to enjoy the same things that I enjoyed in Abu Dhabi…every time when an election comes round, our local leaders promise to bring electricity, but every time they fail to implement this…once they even placed electricity pillars in the villages and took money from the villagers as a connection charge, but something happened, and we never got electricity! I

[45] Villagers often referred to me as a city girl

bought this DVD player for my family five years ago but never got a chance to use it at home: my wife kept it safe, and now I use it at my shop with the Purobi line".

Similarly, Taslima shows the electronic appliances that her husband received from Qatar and mentioned that she has never been able to use due to lack of "proper electricity" facilities.

These quotes highlight the diverse perceptions of what life without electricity access means to members of the communities I visited in Sandwip. Moreover, due to the strict regulation of solar home system providers (POs), the users are not allowed to use devices that are forbidden by the providers during the period of warranty time. For example, an electronic appliance such as a fan or the extension of lights is not permitted by the provider to ensure the durability of the battery. To extend the duration of the services, the POs highly recommended the users not to use more than two lights at a time, if the users want to use the television they must switch off all the appliances i.e. lights of other rooms. I asked the manager of POs, why users are not allowed to extend the wires and use other home appliances? Particularly I was curious why do the POs are so strict on using a fan as, for me, being able to use a fan in 36-40-degree temperature is desirable for anyone.

Mujibur Rahman, manager of Mati Solar explains,

"*a fan consumes more electricity than a small light…people switch off lights when they go to bed at night, but fan is the murderer for a battery, no one is going to turn off a fan when they go to bed…sleeping in the nice breeze from fan is so enjoyable, no one is going to switch it off...this will drain all the charge from the battery and in the morning there won't be any charge left in the battery…the customer will blame our product, will think that our company provides a bad product that's why the charge in the battery doesn't last long. Besides, if anyone overuses the battery all the time, it won't sustain long…thus we strictly forbid our customer not to use a fan or any other electronic devices that need to run continuously*.

Nonetheless, it is true that although people in Sandwip prefer solar lights compared to a kerosene lamps, they are not happy with the quality of the lights that they get from solar home system technology. Mainuddin, a school teacher told me *"no doubt solar helps us to see better compared to a kerosene lamp, but it is not as bright as electricity... we spend a lot of money for such a poor quality of lights…I am worried about my children's future, their eyesight…I can see in my school students are getting eye glass at the very early age…I am worried my children might need eye glasses too".* Interviewees presented a variety of perspectives about life without "proper electricity". They explained how 'having electricity' means that you can use electricity for productive work, for entertainment, to iron clothes, use a fan or freezer, and

experience the freedom of using various electronic devices, without having restrictions on the use, or flexibility in a routines. Both the technology and the smaller capacity of the solar home system do not allow owners to use a range of electronic devices that are widely available in the market.

I spent an extensive amount of time with a number of families in Sandwip, including Mainuddin's family. At one point during my stay Nazma, wife of Mainuddin, shared with me how she lost her three-year old daughter as they were unable to provide proper medical facilities to her: "*In Sandwip you cannot do big medical tests or any serious operation because we don't have electricity. To do big examination you need proper electricity, the doctor here can deal with basic problems, but once it gets serious, you need to go to Noakhali or Chittagong. My daughter was born with a health problem, we always had to travel to Chittagong for her tests and the treatment…the day we lost her we couldn't reach Chittagong on time as it was monsoon time and the sea was very rough. If there was electricity in Sandwip we could have saved our daughter by providing the right treatment...your uncle, and I often blame us, if we had moved to Chittagong after she was born, we could have given her appropriate medical services…we were too emotional to leave our ancestral land, and now we have to carry this guilt and burden for the rest of our life".*

This emotional encounter speaks clearly to why people in Sandwip do not consider solar as "electricity", and why electricity from solar is considered "just solar". While the transition of solar energy technology has helped the villagers to reduce dependency on other sources of light and electricity such as the kerosene lamp and generator, it has failed to displace the use of kerosene lamps entirely. Due to the limited storage capacity of a solar home system battery and limited supply time of solar mini grid, solar technology users need to maintain an arrangement of various source of energy. Some female respondents stated that "we cannot trust solar… always need to keep a backup". The everyday struggle of living with limited light highlights both the practical and emotional struggle of people who live in off-grid areas, and has revealed several critical aspects that numerical data alone would have failed to recognise.

I have observed here that solar energy users have developed various strategies to live with little electricity; they get from solar technology such as combing multiple source of lights and electricity, using alternative or small devices when their battery is running low. For instance, to save the solar electricity from a solar home system the solar energy user prefer to watch films on their mobile phone instead of television. According *Asma "living with solar means you always need to plan your work, prioritise your need and justify your use, otherwise, you will be sitting in the dark".* This sentiment asks a crucial question that post-development scholar have posed: *What is development?* Access to a couple of light bulbs and connection to mobile

phone - what kind progress can be expected? This question will be explored in further detail in Chapter Seven.

6.7 Conclusion

The chapter has analysed the everyday lived experiences of off-grid people who live in a geographically formidable area. At the beginning of this chapter I demonstrated how Sandwip's remote location has made it a key target for introducing small and decentralised energy systems and how, as a consequence, the solar home system and solar mini grid have been developed in homes on the island. In this chapter I have explored the various forms of energy provision in Sandwip including how people in off-grid areas manage their day to day energy needs. I noted how prior to the arrival of solar energy technology, the villagers were dependent on kerosene lamps, the Government line, generators, rechargeable batteries, and charging stations. However, in this chapter I have illustrated how solar energy does not provide sufficient electricity to replace these various forms of energy that people in Sandwip used to use.

In this chapter I have further argued that despite financial support from IDCOL, the price of solar energy home systems is still beyond the capacity of many inhabitants in Sandwip. In addition, the tariff for electricity is 6-8 times higher than the tariff from national grid electricity. The tariff was set by the mini grid electricity provider comparing the bill with the most expensive energy provision i.e. the generator, rather considering the resources available to the villagers. Thus, the decision to adopt a solar energy technology is not a straightforward one for the villagers. It is, rather, bound up in the political-economic and socio-cultural context of electricity. The case of Sandwip Island suggests how the current practices adopted by solar advocates have failed to deliver energy access for all.

The chapter revealed that although solar energy in off-grid areas has been delivered as a means to give electricity access on Sandwip, the technology is not perceived as electricity by the community. In this chapter I have shown how access to electricity is understood to mean the freedom of using various electronic devices and having flexibility in an individual's routine. The limited capacity of solar technology used in Sandwip does not provide either of these freedoms, and so makes solar electricity inferior to grid electricity. This is an important contribution of this Chapter. Furthermore, while the solar energy technology brought lights to homes and allowed the residents of off-grid areas to run small home appliances like mobile phone, radio, television, it failed to provide medical facilities in their lives.

More than a decade ago Neiwenhout et al. (2001) highlighted the dearth of information relating to the actual lived experience of users with solar energy. Cherni (2008) argues that there is

an urgent need for greater evidence to be uncovered on the experiences of renewable energy technology interventions to determine whether technologies are actually fulfilling the practical energy needs and priorities of users. In exploring the everyday life of Sandwip's villagers and drawing upon my extensive ethnographic fieldwork, I have contributed to this literature, demonstrating the aspirations, experiences, and needs of people in an off-grid area and how they manage their everyday energy needs. Through placing the end user at the centre of analysis, this chapter responds to calls in the literature for such analysis, building on and adding new empirical insights to debates over end-users' experiences with small scale solar energy technology in rural areas in developing countries.

This chapter therefore contributes to the thesis and broader literature in two key ways. First, this chapter pays attention to the user's perspective, presenting an analysis on the local level implications of solar energy technologies in an off-grid area. It embeds the perspective of households adopting, using, maintaining and sustaining themselves with solar energy technology. Second, in its close focus on user perspectives in a remote rural area, this chapter has contributed a distinctive spatial context to the policy-related literature on experiences of off-grid electrification programmes. The following chapter will therefore explore that impact of solar energy transition on rural development.

Chapter Seven: Solar Energy for Rural Development

Figure 7:1 Light from solar home system technology. Source: Author

7.1 Introduction

"The provision of one light to poor people does nothing more than shine a light on poverty"

Kahndeh Yumkella, the Director-General of the UN Industrial Development Organisation, 2009[46]

This chapter explores the impact of solar energy transition in off-grid areas and extends arguments made in the previous chapter (Chapter Six). Using Arturo Escobar's (1995) idea of 'development as a social imaginary', this chapter argues that solar energy for rural development is a powerful social imaginary that materialises both an ethic of care and an ethic of commercial interest. According to Cross (2013) solar-powered light is a brand name commodity that successfully assembles a wide array of concerns and interests, politics, moralities and ethics. Chapter Two observed how, in the literature, solar energy technology is seen as a life-altering device for accelerating development by providing income generation opportunities (Barua, 2001); reducing the costs of fuel such as kerosene (Komatsu et al., 2011); reducing pollution; providing a higher quality light and more hours of light in the evening (Mondal and Klein, 2011); and reducing work for women who have to clean kerosene lamps (Barua, 2001; Mondal and Klein, 2011).

Inspired by Cross (2013) here I argue these are the concerns and interests, politics, moralities and ethics that make solar energy technology as commodity and fulfil the neoliberal agenda through the discourse of development. In order to understand the impact of solar energy transition for rural development, I decided to engage with four of the most popular 'ethics of care' that have often been claimed by solar advocates such as the state, NGOs, private organisation and international donor organisations when they justify the need for solar electrification in developing countries. These are: (1) solar electrification for poverty alleviation; (2) education; (3) gender equality and (4) women's empowerment.

The chapter draws on interviews and participant observation with households associated with the solar home system and solar mini grid programmes introduced to Sandwip Island (see Chapter Six). Through these methods, the chapter highlights two critical aspects of solar energy transition and development. Firstly, my findings demonstrate that, while the claims made by solar advocates such as the state, donor agencies and NGOs, and private companies

[46] Cited in Bazilian and Jr., 2017

to justify dissemination of solar energy technology are partially true, these claims fail to capture the bigger picture of everyday life for off-grid populations (discussed in Chapter Six). Secondly, solar energy programmes in Bangladesh have failed to recognise the heterogeneous needs of off-grid people and, as a result, overlook the value of class and gender analyses and the vital role these can play in the adoption and development of solar technology programme.

The chapter is organised around the four dominant social imaginaries and ethics of care associated with solar energy technology in Bangladesh. First, the chapter explores the relationship between solar energy transition and poverty alleviation (Section 7:2). In this section I investigate what impact solar electrification has in terms of income generative activities and to what extent solar electrification creates jobs for off-grid areas. Second, the chapter focuses on education. Education is considered one of the main drivers of development, thus in this section I look at how solar energy contributes to improving children's education. And finally, the chapter explores the relationship between solar energy transition and gender issues.

7.2 Solar Energy for Development: Poverty Alleviation

In Chapter Five we have seen that various assumptions have played a crucial role in creating a market for solar energy in developing countries. Poverty alleviation has been one of the main influential "ethics of care" for the dissemination of solar energy technology in developing countries. Here, I argue the primary ethics of care for solar energy technology dissemination, not only in Bangladesh but also in other developing countries, is the discourse of poverty alleviation. Solar advocates claim that solar energy technology contributes significantly to reducing poverty by creating jobs and allowing people in off-grid areas to engage with income generative work (Asif and Barua, 2011; Mondal and Klein, 2011). Pode (2013) claims that income for some businesses has doubled with installation of SHS. It is worth recalling that, when solar energy transition started in Bangladesh via micro-finance NGOs, the primary target customers for those NGOs were micro-credit borrowers who were part of social enterprise programmes. It has often been claimed that the solar home system allows shopkeepers (member of the micro credit social enterprise programme) to work extended hours which supports these entrepreneurs to earn more money (Barua, 2001).

However, my intensive engagement with the villagers on Sandwip revealed that the solar home system has made a limited contribution towards income generative activities. I learnt that poor people on Sandwip do not use solar home system technology for income generative activities. The most popular claim in the international development sector is that shopkeepers in off-grid areas can keep their businesses open until late and earn more when they use solar

energy. I was informed that, due to limited capacity, the solar home system fails to provide enough electricity for the running of business activities. Local traders told me why the solar home system cannot help them to run their business because nights are longer than the storage capacity of a solar battery. Therefore, with only 3-4 hours of battery backup, the shop keepers cannot cover a whole night.

Aminul Islam, a tea stall owner at Muchapur (Figure 7:2) explains,

"*I need to run a number of electronic devices continuously to attract my customers. I have a colour TV, radio, some bright lights. With solar, I can't run the TV continuously, and most importantly colour TV needs more electricity than a black and white set, which I cannot afford*".

Similar thoughts were conveyed by Kabir, a shop owner at Haramia,

"See…how many lights I need to have for my shop! So as a business person, I always need to make sure that I have enough bright lights so that the customers come".

Likewise, Nural Islam says,

"*Light is like magic; it works like a magnet. It attracts buyers; no one would pay a visit to a dark shop, thus having a continuous supply of electricity is important for any business*".

Nurul Islam goes on to confirm how

"Probably small shops like cigarette or betel nut shop owners can use a solar home system, as their customers do not stay long in their shop: they just come, buy and leave…the majority of the stores in this market use a generator or the mini grid".

Figure 7:2 Generator connected tea shop. Source: Author

Shops that I visited in the Muchapur and Haramia areas all are connected either to the Purobi mini grid or generators. For them the available solar home system technology does not have the capacity to meet the commercial need of business entities. Asaduzzaman et al. (2013) believe two possible reasons for why SHS user household are not involved with income generative work: firstly, the SHS per se does not lead to income generative activities IGAs in general because of its limited capacity and secondly, SHS users are usually financially better off: they are not generally involved in income generative work. In Chapter Six we have seen how, despite having financial support from international development agencies, both solar home system and solar mini grid systems are still beyond the capacity of many poor households. Therefore, solar energy in off-grid areas tends to be used by middle income groups who have stable income and can afford the down payment for solar technology instalment. Jacobson (2007) find similar pattern in Kenya. Thus, Rahman and Ahmad (2013) believe that overall rural development in Bangladesh has not been influenced significantly so far, even with widespread dissemination of SHSs. For them there is no link between SHS and rural development when the indicators of the Human Development Index *(*HDI*)* and World Development Index (WDI) are considered.

Several respondents believe that the lack of access to electricity has made Sandwip unpopular for the younger generation. There is a tendency among young people to leave the island for better opportunities. Some respondents believe that if Sandwip had “proper electricity” several employers would hire some of the young male folk.

For Aslam, for example, *“lack of access to electricity has left us with limited job opportunities and employment”.*

Aslam adds, *“we have limited employment on Sandwip because we do not have enough opportunities. The jobs we have here are just some jobs with NGOs; some government jobs which are mostly held by outsiders; we have farmers, some businessmen, some medical staff and that’s it. Because we don’t have electricity, we don’t have a variety of jobs.*”

He goes on to say how he believes *“the Sandwip economy is mainly dependent on remittances: in almost every household you will find one or two male members living in Dubai, Saudi Arabia or Qatar, or Doha. If we had proper electricity like Chittagong and Noakhali, Sandwip could have at least some factories, some garment industry; at least one thousand jobs would have provided income to a thousand families, so now to earn money either you go to Chittagong, or Dhaka or abroad”.*

Additionally, several literatures claim that solar energy helps to create income-generative work, not only for men, but also for women (Asif and Barua, 2011). However, Asaduzzaman et al., (2013) do not agree with this claim: their research asserts that women from non-user households are more involved in income generative activities (IGA) than those for SHS user households. Here, I would like to emphasise that socio-economic class generally determine women’s involvement in income generative activities in Bangladesh. According to White (1992) class and women’s relations with income generative activities are intricately intertwined in rural Bangladesh, and one cannot be studied without looking at the other. In Bangladesh, poor women have in recent years gained considerable acceptance in public spheres as they have joined the labour force as cheap/replaceable female labour. Whereas middle class women, who may be slightly better off, are often more constrained by socio-cultural behaviour and getting involved with income generative activities are not widely accepted in rural Bangladesh. In Chapter Six we have seen that solar energy technology is adopted by middle income groups or the families of migrant workers who earn a substantial amount of money compared to a local day labourer. Thus, it is these women who generally get involved in income generative activities. In addition, on Sandwip women that I interviewed believed the solar home system runs for only three to four hours, and they struggle to cope with their general household chores within these limited hours. Thus, using the solar home system for

income generative activities is not possible. Mondal and Klein (2011) strongly believe that in a few cases income has been raised among solar home system users, but the volume of increase will not be significant at current rates for income and inflation, and thus it should not be used as a substitute for comprehensive tools for poverty reduction and rural development.

7.3 Solar Energy for Development: Education

Education is fundamental to human development and growth. The importance of education in early life – and especially in childhood - for both personal development and economic development was recognised more than twenty years ago by government officials and development organisations. With the broad aims of improving people's lives globally, world leaders declared Education for All (EFA) as a goal in April 2000 at the World Education Forum in Senegal, Africa (King, 2011). Here, I argue that there is a second 'ethics of care' associated with dissemination of solar energy technology in developing countries, especially in off-grid areas, which centres on solar energy's role potential role in increasing access to education. It is believed that household electrification enhances children's access to education in general and girls' education in particular. Figure 7:3 below is a brochure for Solar Aid that I collected when attending a 2014 conference at Sussex University. In this figure (7:3), produced by the charity Solar Aid, we see a picture of a child studying with a solar lamp. Here, Solar Aid are urging greater financial support for under-privileged children in Africa. The messages that this image presents - "A little light goes for long way", and "solar lights improve health, save money and allow children to study after dark" - can be considered ideal examples of Redfield's (2012) 'humanitarian goods' (cited in Cross, 2013).

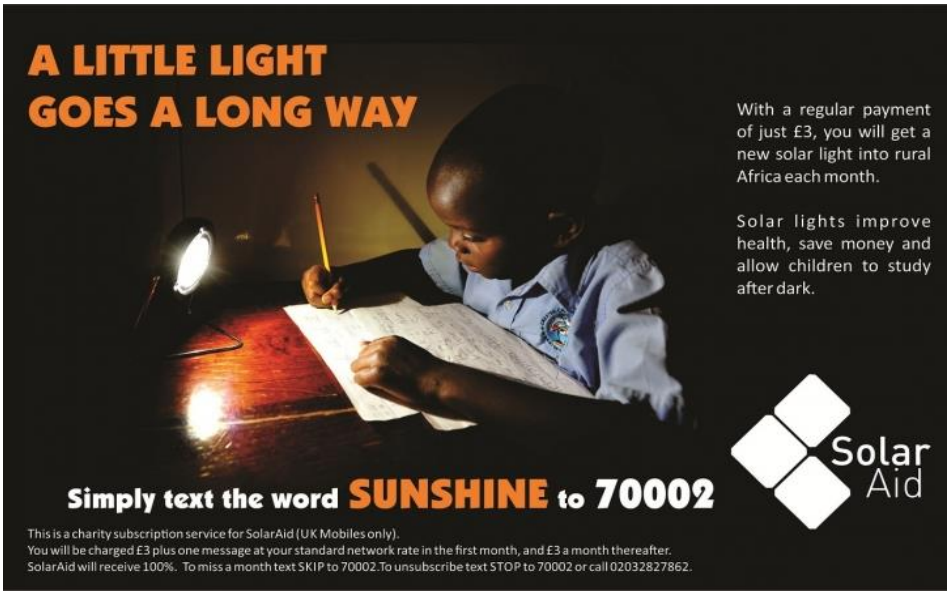


Figure 7:3 A charity brochure for urging financial support for solar electrification

A number of informants agreed that one of the main reasons for buying solar energy technology is children's education. Similar findings were also found in other literature (Bazilian, et al 2014; Miah et al., 2010; Sharif and Mithila, 2013; Mondal and Klein, 2011). This sentiment has also been echoed in other geographical contexts (see Chaurey et al., 2004; Pachauri et al., 2004; Rao 2013; Khandker et al., 2012; Kanagawa and Nakata, 2008; Srivastava and Rehman, 2006) such as other countries in South Asia and in Africa.

For Asma Begum, a house wife in Sandwip,

"I bought this solar three years ago. I have two children; one goes to school and one is two years old. My reason for buying solar was my children's education: my son needs to do homework at night. He used to use a hurricane lamp for study which was not bright. I asked my husband to buy solar so that our son can study well...I realised that solar is also good if you have a small kid. When my first son was born, I always had to worry about him, if he touched a Kotta (lamp) or a hurricane lamp. But now my little one can play and walk; now I don't need to worry about him".

On Sandwip the solar energy users that I interviewed told me that 'people on Sandwip buy solar technology to avoid fire hazards associated with kerosene lamps'. In a study Mashreky et al. (2009) reported that, in one year, around 2.6 percent of households surveyed in Bangladesh and around almost 173,000 children in the country suffered from burn injuries. The adoption of solar home system is assumed to help reduce fire hazard (Khan et al., 2012). Here, I would like to flag up that while adoption of solar technology may have reduced the fire risk from kerosene lamps, solar energy technology is not able to meet the energy demands of cooking. Solar energy users in Sandwip still use firewood for cooking and, as a result, the risk of fire hazard still remains in the domestic sphere. Thus, the inability of solar technology to replace traditional cooking fuels not only exposes the off-grid population to fire hazard but also exposes the population (and women and children in particular) to serious health and environmental consequences.

It is true that although people on Sandwip prefer solar lights compared to kerosene lamps, they are not happy with the quality of the lights that they get from a solar home system technology. While solar energy users agreed that solar technology makes off-grid life easier for preparing homework for students, solar energy technology fails to offer opportunities for vocational training or various forms of education that are not limited to academic institutions. Some of the respondents argue that solar technology may help a child of a family to access

formal education, but solar technology does not support long-term solutions such as vocational training, non-formal education, or creates job for educated people.

According to Mainuddin, a school teacher,

"*what if better education can't ensure a job in their village, if they need to leave their ancestral home? After college, you need to go to the city for higher education. Even after higher education, our children do not have many options to come back here and stay with their family due to lack of electricity*".

Farida's concern brings gender into our conversation,

"*Education is important for both boys and girls. But if you think about our culture there are certain types of education that are more important for boys and others that are more for girls. My daughter wanted to learn baking as she got inspired by her cousins who live in Noakhalhi. My daughter asked her father to buy an oven so that she could bake a cake like her cousins. How could she bake or learn to cook nice food? I saw my nieces in Chittagong: they bake brilliant cakes, but our misfortune is I can't provide any opportunity to my daughter to bake cakes".*

This conversation is reminiscent of Kumar's (2015) argument that when world leaders and international development agencies characterise poor people's needs, they fail to acknowledge the heterogeneity within one location, let alone the variety of needs at different geographical localities. According to Kumar (2015) "some common elements contributing to heterogeneity in the Indian scenario are class, caste, gender, age, knowledge and migration patterns. These elements greatly impact peoples' needs, wants and aspirations…heterogeneity has a deep bearing on actual and aspired electricity uses and is reflected in people's ideas of electricity access" (p. 9). For these and other similar reasons, post-development scholars such as Rahnema (1997) expresses reservation towards the idea of development: Rahnema argues that the way the development concept is applied to its 'target populations' is basically the wrong approach as far as their needs and aspirations are concerned. For him (and other authors, such as Esteva, 1987; Sachs, 1992; Escobar, 1995) development is an ideology that was born and refined in the North, mainly to meet the needs of the dominant powers in search of a more 'appropriate' tool for their economic and geopolitical expansion.

The above section challenges the unconditional and popular discourse of solar electrification driving rural development and related processes such as job creation and educational attainment. While the users of solar energy acknowledge its positive impact on off-grid life,

they also highlight the drawbacks of solar energy technology such as poor quality of lights and limited facilities to power home appliances. The conversations with solar home system users also confirmed another critical aspect that was discussed in a previous chapter (Chapter Six): the homogenisations of rural people's needs (Ferguson, 1994). Like Farida, other mothers on Sandwip that I talked to express their frustration at not being able to provide access to modern technology for their children. The way the need for education is perceived fails to address the spatial (i.e. place-based) and socio-cultural value of education: for example, having access to education but not being able to provide jobs in their own village is a real challenge for many off-grid inhabitants that I came across during my fieldwork. This frustration directly links back to the argument that current solar energy technology in Bangladesh has only a limited capacity to create large-scale employment in the way that grid electricity does.

7.4 Energy for development: Gender Equality

Gender is socially constructed, the notions of gender are neither fixed, nor historically and geographically specific. 'Gender' refers to the socially-constructed roles of and relationships between men and women. Many feminist scholars emphasise the importance of gender analysis: as a diagnostic of unequal social relations, it allows entry to understanding multiple forms of social norms, value, oppression (Kabeer, 1994). Although here is no necessity for gendered relationship to be inherently conflicting, a gender-based analysis draws attention to the ways that differences and inequalities operate in the context of gender. Thus, gender equality is understood to have equal rights, responsibilities and opportunities of individuals (Warth and Koparanova, 2012). Here I want to emphasise gender equality is not just a "women's issue"; it is necessary that partnership between all the sectors of society would lead to equal valuing of the differences and similarities of the two sexes.

Energy access is not gender neutral, this research reveals unequal energy access and energy distribution in off-grid households. For Sen (1990) the household is not a monolithic altruistic black-box, but rather a site of 'cooperative conflict', whereby household operations are based on negotiations between members. The relationships between power and patriarchy are maintained by both men and women in households, and Gibson and Graham (1996) posit that even within a socioeconomic bracket, all members of the household do not necessarily have the same control over resources. Here it is important to note that a solar home system comes with different kinds of light bulbs: one or two bright lights and a few other dimmer lights. Generally big, bright lights are set in the living room as bright light symbolises the family's status (Kumar, 2015a) and the living room has multiple purposes. It can be used as a living room, a study room for children or as a guest room (Figure 7:4). Many scholars argue that children's education is one of the main purposes for buying an SHS for many rural families

(Komatsu et al., 2011). If a household has children who are going to school, the priority use in that house will be for the children to be able to complete their homework after dusk. Thus, the best light is used for the most important work i.e. children's education and the most important room, i.e., the front room of the house. The rest of the lights are distributed based on the family hierarchy, deliberated priority, and power relations.

Figure 7:4 The brightest light is set in the front room for homework Source: Author

Sultana (2007) argues a household is a stratified unit of people with different powers, endowments, rights, and positions in a hierarchy. Both family and household structures are quite hierarchal in rural Bangladesh. Here I emphasise electricity access in kitchen area, an area traditionally considered women's territory. The location of the kitchen within a homestead area thus becomes important. In traditional households in rural areas, kitchens and cooking facilities are generally separated from the main house and located in an open space. As the normal SHS unit operates well only within a given distance from the charge controller, which is usually located within one of the main rooms, kitchens may go without any lighting points from the system. As the most popular packages usually offer only a few connection points with one usually reserved for a TV and another for charging mobile phones, kitchens may often go without lighting from solar electricity (Asaduzzaman et al., 2013). Nonetheless, if the kitchen has a connection, it has been observed that most of the kitchens get the dimmest light as

kitchen space isn't considered as an important space in the house. The following picture of a kitchens confirm the negligence of kitchen space. In this figure (7.5) we can see a separate kerosene light is used to eliminate the darkness of the kitchen.

Figure 7:5 A Newly built kitchen adjacent to the house has the dimmest light thus a kerosene lamp was needed to see things properly. Source: Author

In the previous chapter (Chapter Six, Section 6:5) we have seen, many off-grid households decide to purchase a small capacity solar home system compared to what actually is needed in order to reduce the cost. Thus, to utilise this limited energy most effectively a solar home system owner always needs to negotiate their family's priorities. A number of housewives I interviewed actually justified why they have decided not to have any bright light in the kitchen. For example, according to Afroza "we struggle to distribute the light the important part of our house, kitchen is not in our priority". Here it is important to mention that the ability to bargain in a family is based on the perception of contribution that individuals make to the overall well-being of the household. According to Sultana (2007) women in Bangladesh generally have weaker bargaining positions in their households as their contributions are often non-monetised or invisible. As women on Sandwip are primarily contribute in non-monetise domestic role

only, cultural expectation never crosses the women's mind that this is an unequal distribution of lights.

In any case, this illustrates the importance of the number and locations of points of connection for lighting. Hence, the scope for kitchen lighting with the SHS may be somewhat complex. As the solar technology used on Sandwip has limited capacity, the users always need to choose between tasks and prioritise their needs and on many occasions, it leads to family conflict between members of the family and sometimes with neighbours. Amina told me she always needs to fight with her son who is a great fan of cricket. "*You know…young boys love cricket, and my boy love cricket, he wants to watch the full match, but I can't allow him to do that. If he watches the full match there won't be any charge left in the evening to use. I cannot do it because I don't want to sit in the dark at night"*. Asma explains sometimes she falls into a difficult situation when she needs to say "no" to her children or neighbour.

Asma "*It is so difficult to say no to your children and relatives when they want to watch or use electricity from solar"*.

Raihana "*I can understand your feelings, but could you elaborate this more*"?

Asma "Often there is a misunderstanding created between my relatives who happened to be our neighbours? Our relatives next door has not got solar yet, as her son does not earn a lot, but she charges her mobile phone from our system. If there is not any sun, if the battery is running low, if I say no to her using the phone charger, she takes it badly. She thinks I am being horrible, or neglecting her because she is poor or refusing to let her use the phone charger without any valid reason…she goes to other relatives and tells them bad things about me...which is so unfair to me".

Asma "On other hand, you always need to be watchful about your own use and sometimes I have to be strict to our children about their use too because my husband doesn't like having no solar when he gets back from outside…it is difficult to make your children to listen all the time, sometimes they watch TV, sometimes they don't want to be in the same room, sometimes they do fight with each other… they don't want to study in the same room".

Raihana "It sounds very stressful to manage all this…"

Asma " *mmm…it is stressful, but you just get used to it after a while, but sometimes when your own people misunderstand you, when your husband, children and relatives do not understand your struggle, it makes me upset*".

This is a common sentiment often shared by the solar energy users that I interviewed that 'sometimes solar energy creates misunderstanding' (will be discussed further in section 7:4) and family conflict among family members and relatives. The following research diary note reveals not only social relationship but also a mechanism for how a solar energy user manages their day to life and relationships with family and neighbours.

Text box 4

Research Diary: Date 25/01/2013

It is a Friday afternoon, the weekend in Bangladesh. Parvin Akhter and I were sitting in the front yard and enjoying the pleasant warm winter sunshine after lunch. Parvin and I were chatting casually. While we were chatting, 3/4 children from the neighbour came to see Prapti. Prapti was inside of the house, Parvin informed Prapti that her friends have come to see her. As soon Prapti came out, her friends took her aside and started whispering. By the look at the crowd and their whispering, it seems like the kids have some secret discussion about something that they don't want to talk in front of Parvin Akhter. After a while, Prapti came to her mother and asked, "mother can I turn on the tv and watch the Friday film with them". Parvin replied, "I don't think it is a good idea as the battery has not charged enough because the morning was not bright in the morning". She added, "let me check, and after that, I'll decide".

Parvin went inside of the house to check. I followed her too to see how she decides. Curiously I asked Parvin "apa …how do you decide whether you are going to allow them to watch the film or not". She explained she would see the charge controller first and try to understand the battery situation. She explained on a solar charge controller there are three lights, green, orange and red which indicates the battery charging condition. She explained green lights confirm the battery is full which gives her assurance that she has at least 3-4 hours battery, orange is half that means 1-2 hours that means one need to very cautious about the use and red means very little charge left. It is strictly instructed by solar home system provider that when the charge controller shows red light one should not use the system at all until the battery gathers some charge, otherwise the battery will have discharged completely which is not good for the battery life. However, when we saw the charge controller we found that the orange light of Parvin was bright, so that means the battery has the charge to run electronics appliances for 1-2 hours. She decided not to allow them to watch tele.

Parvin breaks the news to the kids and the kids from neighbour left to their house. I asked Parvin despite having half of the battery charge why she decided not to allow them to watch the film. Parvin explained television consumes more battery. Therefore she doesn't think it is a good idea to turn the television while the battery has charged half from the morning. Parvin "if it were just using one light or charging a mobile phone, I wouldn't mind letting anyone use it, but television drains consume a lot of charges".

After a while, another woman (Farida) from next door came to talk to Parvin. The lady actually came to request on behalf of the kids so that Parvin allow them to watch television. Parvin explained her the battery situation. "Do you need to request me for letting kids to watch the film, I always let everyone use my solar, I am not like them (she indicates opposite house), battery is only charged half, if they start watching film I won't have any battery left for the night, I don't want to sit in the dark" Parvin explained. But Farida insisted on letting the kids watch just for a while. "just for half an hour, after that, you turn off the television".

Finally, Parvin changed her mind and called Prapti to turn on the tv and to call her friends to watch the telly. When the children came, Parvin said: "only half an hour after that no request will be heard". After 40 minutes or so Parvin turned off the tv and asked Prapti to switch on the mini rechargeable DVD player. Prapti turned off the television and played DVD player. I saw kids were not happy with this decision as they were not able to see rest of the film, but they accepted Parvin decision and started watching another film in a small DVD player.

This research diary's note on that relaxed weekend afternoon revealed a number of issues: the social relation with solar energy technology, constant negotiation of a solar energy user household makes. The solar home system that Parvin has a medium-size solar home system that comes with 4 lightbulbs, a connection for tv and a connection for mobile phone charge. The process of making the decision which appliances can be used and for how long entirely depends on family dynamics and power relations in domestic sphere.

In contrast, if we go beyond domestic sphere, we can see a different form of negotiation and gender inequality in the way various form of solar energy technologies are distributed in Sandwip. There is a clear distinction between the services of the solar home system and solar mini grid that intensify gender relations and divisions of labour on Sandwip. Based on the electricity generation capacity, availability of services and duration, the difference between these two technologies is strikingly visible. Because of the way the solar mini grid technology has been designed, it produces guaranteed electricity for a longer duration compared to the

solar home system. On Sandwip, the primary target areas are the bazaar (market place), and the main target consumers are men (Khan and Huque, 2012). Electricity from the mini grid enables collective gatherings of men. It also allows men to watch collective colour TV or talk over cups of tea; whereas women (the primary target of the solar home system) get limited hours of electricity with inadequate capacity to run appliances like colour TV and heavy load machinery needed for heavy work wielding, grinder etc.

The contrast between the loud hubbub and bustling atmosphere of the bazaar, and the quiet, dimly-lit domestic interior space for women is enormous. Bright light and the capacity to run heavily-load machinery in the marketplace confirms the social hierarchy of men's and women's work and social construction. A different form of solar technology not only reproduces stereotyped division of labour between men and women, but it also reinforces gender disparities in access to resources and services.

Figure 7:6 Watching cricket in a Bazaar. Source: Author

To illustrate this, here is an exchange I had with Humayun Kabir, a solar installer on Sandwip

Humayun *"Although my job is to set up solar in people's house, solar doesn't do anything for me".*

Raihana *"Why?"*

Humayun *"It is true that everyone needs lights and uses a mobile phone, but the younger generations like us need more than light and mobile phones".*

Raihana *"What else do you consider young boys and girls want or need that solar cannot provide? Could you please elaborate on what you mean by 'young generation like us we need more than light and mobile phone'?"*

Humayun "*Erm…just to clarify, when I said 'young generation', I was referring to menfolk only. Here young boys like sports, cricket, films; and older men want to know about politics, news, what is happening in foreign countries, these all need a good connection to electricity like in the city, like Chittagong, like Dhaka. The solar that we sell here on Sandwip won't be able to provide electricity like in a city; it cannot run colour TV, a computers CD player, or DVD player to be able to watch a film or a cricket match. So we just hang out in the bazaar, because in the bazaar either you have electricity from generators or government lines, or a line from Purobi. You can run anything you want; you can watch everything. In my house we have 50 wp solar home system, we run lights and a 14" black and white tv. My mother and sister watch TV after work and study for an hour or two. But I don't like to watch black and white TV, so after my job, I come to the bazaar and go back home to sleep*".

Raihana *"Do you not think your sister wants to watch a film or use a computer? Is she from your generation too?"*

Humayun *"Ha ha ha! Apa (sister) …you are a woman and that's why you are concerned about women, but I guess people who do solar business don't think about women, they only think about their profit, and you know in rural areas men and women do not have access to the same things…we do not allow my sister to have a mobile phone; she can have one in future if her husband allows it".*

According to Mohideen (2012) women's and men's perception of the benefits of modern energy can be different. Such differences are important because they affect the ways that decisions are made, benefits are distributed, and the impacts that processes and projects have on women and men in similar contexts. Indeed, it can be said that the conversation with Humayun Kabir suggests that solar energy intensifies existing gender divisions in an off-grid place like Sandwip. It is clear from this exchange that different forms of solar technologies enforce the reproduction of gender inequalities.

7.5 Solar Energy for Development: Women Empowerment

Gender equality is understood to have equal rights, responsibilities and opportunities of individuals, not dependent on whether they are born male or female. However, gender relationships in Bangladesh is inherently unequal. Women empowerment has been the instrument to achieve gender inequality. Empowerment is defined as what happens when people, individually or collectively, conceive of, define and pursue better lives for themselves and their ability to make choices (Kabeer, 2010). The notion of 'empowerment' has emerged since the 1980s as an important theme in development, especially concerning other marginalised groups. Empowerment is the expansion of assets and capabilities of poor people to participate in, negotiate with, influence, control, and hold accountable institutions that affect marginal groups of people (The World Bank, 2002, p. 11). Winther et al. (2017) argue energy policies rarely address gender issues explicitly. According to Clancy et al. (2011) national policies for electrification are often gender-blind or they primarily focus on women's domestic roles (Kelkar and Nathan, 2005).

A tendency has been observed in the literature that a set of welfare indicators- such as women's employment, time used for domestic chores and fertility rates- are measured across large samples without being able to account for factors other than electrification to explain the observed effects (Winther et al, 2011). My engagement with the everyday lives of both solar home system and solar mini grid users on Sandwip made me realise that it is important to look at who does what with which type/source of energy, why and where, and also what such relationships mean for broader societal issues in order to understand the relationships between energy access and women's empowerment. The following section explores some of the aspects that appeared in several discussions on Sandwip with both male and female respondents.

Women have often been seen as 'passive users and consumers of energy' (Clancy, 2004, 19). A common tendency was observed among scholars who explore solar energy diffusion: women are placed in a position with a greater emphasis on benefits related to improving health care and children's education, reducing expenditure, reducing their workload, and improving household safety (Amin and Langendoen, 2012; Islam et al., 2011). According to an IDCOL report, women have been the main target beneficiaries of SHS programs by various Partner Organisations (POs) because women are traditionally responsible for household energy needs and have been rescued from this onerous task by the installation of SHSs. Several solar actors advocate for the technology on the grounds that women will be liberated from many chores; they no longer need to clean kerosene lamps every evening and can finish their household activities more efficiently and in less time. In addition, it is believed that energy

access in rural areas helps to empower women as solar energy eases women's lives by providing better light (Sharif and Mithila, 2013). While a growing body of literature talks about women's roles in energy programmes and the impact on women's lives, many scholars have ignored the broader societal factors at play in the ways that gender is implicated in everyday energy access, energy services, and energy consumption.

On Sandwip island there is a common perception among NGO workers as well as the villagers: women are seen as the most likely beneficiaries of solar energy users of solar energy as they stay at home most of the time in off-grid areas of Bangladesh while their husbands live abroad. On Sandwip there no doubt that both the solar home system and solar mini grid have provided a little comfort as the illuminating quality of solar technology is better than a kerosene lamp. A common response was 'solar makes life easy'. School teacher Mainuddin says,

"*with solar our life become so easy. For example, if I need to search for anything, before I had solar, I had to search for matches then light the hurricane lamp or kerosene lamp, then I could find whatever I was looking for. But now with solar, I just need to press the switch and find the things that I want. Truly solar makes our life so easy*".

A seventy-five year old solar home system owner, explains the benefit of solar energy in her life is that she can see things better… "*I don't bang into (things) now, before I used to bump to here and there, even hurt (myself) many times". "With solar life become so easy,"* said Anowara Begum. "*Before solar, we have batti (kerosene lamp) and hurricane (lamps). It is so annoying to clean the chimney of the hurricane lamps every other day; now I don't need to clean anything, just turn on the light".* Thus, the islanders try to adjust and adapt with the best option available on Sandwip.

Many solar advocates believe that solar energy technology brings comfort and convenience to off-grid life. According to Humphreys (1995) comfort is one of sufficient possibilities for adjustment and adaptation. It is also viewed as an achievement. In contrast, convenience is about timing, the ability to shift and juggle obligations and to construct and determine personal schedules (Shove, 2003). I argue that the limited capacity and the limited hours of availability (3-4 hours) of solar technology does not allow both men and women to shift their daily chores to a great extent. It certainly helps women to not have to rush cooking before dusk comes, and it allows family members to see objects and books more easily with solar lights. However, limited hours of electricity service and limited permitted appliances do not provide convenience to the off-grid residents. For instance, both Mainuddin and his wife express their dissatisfaction in not being able to have a refridgerator.

According to Mainuddin,

"*I do not have time to go to the bazaar everyday to buy fresh fish or meat, but I have to do it…if we have proper electricity I could have gone to the bazaar once in a week and use my time more efficiently".*

In contrast, Nazma, wife of Mainuddin said,

"*I don't feel like cooking everyday. Sometimes I feel unwell and I want to skip cooking, but I can't do that, I need to cook everyday, sometimes two times, during the hot season…if we had a freezer I could have cooked for a couple of days and we could eat from the freezer".*

Often people (both scholars who have written about the impact of solar energy and local people who I spoke to during my fieldwork) state that 'solar makes women life easy'. Women don't need to clean hurricane lamps everyday, women don't need to think about storing of kerosene oil or running out of kerosene oil storage.

Dilara Begum, the wife of a migrant worker said,

"*since I live alone and there is no male person in my house, always I had to wait for somebody to charge my mobile phone or to buy kerosene oil if anyone is going to bazaar from my neighbour house. Before solar, I always had to worry to come back from outside before sun set, otherwise my house will be dark. If I am next door to chit-chat with my neighbour, I had to make sure that I am back before dusk*".

Access to solar electricity and women empowerment are consider inseparable in the development discourse. A documentary was in released in 2013 by the World Bank entitled Women Empowerment by Solar Energy in Bangladesh (Figure 7:7). Asaduzzaman et al. 2013 note the most general outcome of the adoption of the SHS, albeit the most difficult to measure, is the extent of women empowerment. Moser (1993) suggests women's empowerment can be divided into the following aspects: sense of security and orientation towards the future, income capacity, competence to be active in public in an effective way, power to take decisions in own household, participation in non-family groups and utilisation of solidarity groups, as well as access to information sources and support resources, mobility and visibility in the community.

Figure 7:7 A documentary by the World Bank in 2013[47]

However, I had an interesting conversation with Professor Pasha, a retired professor of South Sandwip College. According to Professor Pasha *"Solar is a blessing for women. It is very useful to women, but it doesn't do for men as much as it does for women*". For him solar makes women's work easier and it also gives them the freedom to enjoy their time. *"After solar, I don't need to wake up your Chachi (Aunty)* (wife of Pasha) *to light up the hurricane lamp to go to the toilet, now she can enjoy sleeping without any interruption*". He explains how solar doesn't change anything in his life. After college he spends his time in the bazaar chatting with his colleagues and friends, therefore it doesn't offer anything extra to his life. On the other hand, women stay at home and women need to organise the lights for when it is dark; therefore it is useful in women's lives. Therefore it can be said that access to modern energy (in this context solar energy) appears to enable women to fulfil their traditional roles (to their satisfaction and well-being) rather than bringing significant transformation in gender roles (Clancy et al., 2007)

The conversation with Professor Pasha reminds me of what Shaw (1998: p. 384) argues: that 'neo classical economics may explain the increasing hurriedness of men's lives through a progressive shifting from unproductive intro productive activities; for women it is more often the inability to shift out of unproductive activities which are the cause of their ever increasing pace of life' (cited in Shove 2003 p. 172). It is true that women are the greatest users of solar

[47] https://www.youtube.com/watch?v=6K7q7l_BAAk

energy as they stay home more than men, and solar energy can impact women's everyday lives as the timing of household chores becomes more flexible due to the availability of better lighting. Skutch (1998) highlights that access to energy services is not challenging systemic gender inequality and transforming gender relations. Standal and Winther (2016) believe the benefits of electricity projects became limited to helping women in their domestic role (p. 42).

7.5.1 Sense of connectivity

Solar energy technology has enormous impact on people connecting the off-grid areas through mobile phone and television (Jacobson, 2007). Karim, a shop keeper at Muchapur bazaar shares one event,

"*in 1991 there was a terrible cyclone - thousands of people died in that cyclone. That time I was worried for weeks because I was not able to get any information about whether my family was alive or not…. With solar communication it has become super easy and within a second anyone who lives miles away can reach his family*".

A gender-based analysis suggests a more complex picture, however, involving processes of both connection and isolation. Taslima told me that when Sandwip didn't have access to mobile phones women used to write letters to their husbands. According to her they had to wait a long time to hear from other places. Now through access to mobile phones via solar energy communication has been made much easier. However, through the use of mobile phones the women strengthened their social networks through communication with people outside their locality. Tenhunen (2014) finds in West Bengal women's new access to mobile phones has had a positive impact on women with support from their natal families in difficult times. While I was in Sandwip I have heard women mention that now women can talk to their family who lives in Sandwip or outside of Sandwip. Another housewife told "men can go outside and talk to several people, get information, but for women mobile connects with our near and dear".

A number of male migrant workers and their wives said they bought solar just to use mobile phones, not for light. Kumar (2016) also found similar sentiment in his research in India that many solar energy users bought solar electricity to charge mobile. Solar energy is rightfully connecting the disconnected, the migrant workers who do not visit their family frequently, thus the mobile phone is the only device to enable connection with friends and family that are left behind, allowing them to stay in touch. One striking finding from within the families that I worked with on Sandwip was that although the women are staying alone, taking care of the children and acting as custodians of the property, in terms of the decision-making process

they are still heavily dependent on the men who live miles away. Male members of the household made decisions pertaining to daily living even though they live miles away from the household. While solar energy technology connects family with their nearest and dearest, access to easy communication sometimes has a negative impact on women's lives by allowing patriarchal practices to re-emerge via this modern connection. Women are accountable to their husbands to discuss any day-to-day decisions they made. Being able to use mobile phone has given men a controlling mechanism to continue maintaining an awareness of events at home and take all the decisions even though they live thousands of miles away. For example, consider the following exchange:

Afroza "*Mobile phone makes us connected with my husband, but it also sometimes creates problems*".

Raihana "*Tell me more about it Apa (sister)? Why do you think easy communication with your husband creates problems*?"

Afroza "…*Nowadays everyone has a mobile phone, in case anything happens if I don't want to inform my husband he can find out from other people. We had a quarrel several times that I thought I should take a decision immediately and will let him know later. It happened many times he found out from relatives before I told him. He was upset why I didn't tell him before…sometimes I wish I didn't have a mobile phone, sometimes I wish life was better with mobile, he could have less control over me and my decisions…sometimes I feel angry with him, he doesn't stay here but still wants to control everything…but you can't say anything to your husband because men have more power in a family no matter how far he goes*".

Nonetheless, the majority of the migrant workers' wives admitted solar energy makes their life easier in terms of communication with their partners; as they own SHS the women don't need to go to the bazaar to talk to their partner, it not only helps them to save time but also allows them to have private conversations with their husbands. Several interviewees mentioned they suggested to their partners that if they decided to buy a solar home system they would have easier communication, as well as being able to protect family honour by confining women's journeys to the bazaar. Generally, public spaces have been historically construed as masculine spaces, and private/domestic spaces as feminine. According to Domosh and Seager (2001) female bodies that are seen to be 'out of place' outside of the private realm are often seen to be in need of greater control. Traditionally, the concept of good women was linked with regulating female bodies in public spaces, in both limiting their mobility as well as dress code and behaviour. In rural Bangladesh, notions of *purdah* (veiling, seclusion) also

operate in defining appropriate feminine behaviour (Rozario, 2001). Although solar energy saved the women from having to go out to talk to their husband, it also limited their mobility.

According to Latifa,

"now I don't have any excuse to go to the bazaar... before I used to use this opportunity to go out and do some shopping while I had to attend to my husband's call".

Taslima who live with her two children told me:

"Sometimes I feel so suffocated living alone and not being able to see or talk to any adults when I don't see or hear any adult voices for weeks…but you can't go out and wander around the bazaar as for women from our background it is not considered good to go out alone".

In the comments of these two women we can the point made by Laws (1997: p. 52), who notes how "patriarchal social structures and institutions create embodied female identities, and these in turn limit women's spatial mobility". As such, mobility of women and girls can be constrained by broader socio-cultural norms, but are also inflected by age, class, education, and position in the household. While some studies have found that spatial fixity is a problem for women across different social categories (Massey, 1994; Laws, 1997; Kwan, 1999), it is influenced by local customs, norms and endowments of the woman. This conversation raises questions to those literatures that believe that transition of solar energy technology in rural life has enormous impact on women's wellbeing and women empowerment. The isolation that the women on Sandwip mentioned has not been discussed in any of the literature, as this kind of isolation can have detrimental effect on the women's self-esteem and impact their empowerment.

Nevertheless, a number of literature believe there is strong evidence that the content of television programmes may increase women's well-being by giving access to information (Mondal and Klein, 2011; Barua, 2001; Zahnd and Kimber, 2009). For Jensen and Oster (2009) women gained knowledge about family planning and alternative gender narratives which reduced their likelihood of having many children, reducing the fertility rate (La Ferrara *et al.* 2012). Thus, many scholars argue the influence of television has had a direct impact on attitudes and women's social position, which is linked to agency on a structural level. According to Standal, (2010) TV and radio, have opened a space for women to demand being part of family decision-making. Women in rural South Africa also acquired new knowledge through television about women's entitlements with respect to the government. Matinga's (2010) research found women learned about voting processes and how to interact with the

government and other welfare institutions such as enabling access to health services, education.

7.5.2 Sense of Security

Sense of security has always been related to space and place. Many feminist geographers have argued that space is gendered. The gender and space literature highlights how gender is constitutive of and constructs space and spatial relations (Massey, 1994; McDowell, 1999). On Sandwip, the respondents mentioned several times that light from the solar home system and solar mini grid provide a sense of security inside the home, especially for women. The wives of migrant workers whom I interviewed told me that access to solar energy gives them a feeling of safety which is very important for women who live alone. For Nasrin, a housewife in Muchapur:

"*everyone is scared of darkness…living alone without my husband is frightening, after having solar at home I feel better now*".

Amena Begum says she also feels safer because of solar. She believes that when people started using solar on Sandwip, thieves became wary of the lights. She explains,

"*with kerosene light you can see just a face in front of you; you really can't see anything far... since I live along with my daughter-in-laws and there is no man living in our house, I was always scared of thieves and robbers...once there was a robbery in our house: that time we didn't see anything because there was not any light that time*".

According to a documentary released by the World Bank in 2013 it is claimed that crime rate has reduced significantly after arrival of solar mini grid on Sandwip. Thus, the relationship between lights and a sense of security appeared several times in the interviews: although the solar home system programme and solar mini grid have brought lights to homes, there is no lights on the roads which makes it difficult for everyone, but especially for women, to move around in the dark. "Our bad luck is we do not have electricity on the roads; we only have solar at home. There are no street lights, so women don't feel safe to go out after dark," said Taslima.

Figure 7:8 Dark road without streetlight. Source: Author

Mohideen (2012) highlights that little priority is given by governments to invest in public services, such as street lighting, which could reduce women's vulnerability and improve their safety. The way solar energy has been brought to the domestic space by private companies via micro-credit organisations can be considered a process of turning public goods into private assets (Mader, 2011). Making public goods into private assets ignores the fact that a public service should be provided by the state rather than the villagers needing to be responsible for their own electricity. The privatisation of responsibility for infrastructural provision – such as water and electricity - changes the social contract between individual households and the authorities or the state, effectively domesticating infrastructural provision from a responsibility of the state to private individuals (Button, 2017). In other words this process transforms citizens into consumers (Shiva, 2002; Swyngedouw, 2005; Mader, 2011). While street lighting can reduce women's vulnerabilities and improve their safety and mobility, these services are often not prioritised for investment by governments and energy or power utilities.

7.6 Conclusion

This chapter has explored the impact of solar energy technology transition in off-grid areas. Solar energy technology assembles a wide range of concerns and interests, politics, moralities and ethics from various actors and has become a humanitarian product by bringing 'ethics of

care' and 'ethics of profit' (Cross, 2013). Focusing on four areas of development discourse - poverty alleviation, education, gender equality and women empowerment, this chapter has argued that the way solar advocates measure and claim the development discourse is partially true. Ferguson argues "by uncompromisingly reducing poverty to a technical problem, and by promising technical solutions to the sufferings of powerless and oppressed people, the hegemonic problematic of "development" is the principal means through which the question of poverty is depoliticized in the world today" (1994: p. 256). This chapter demonstrated that the solar energy programmes in Bangladesh have failed to recognise the heterogeneous needs of off-grid people and undermined the need for class, gender analysis that play vital roles for the adoption and development of solar technology programme.

The chapter has established that neither SHS nor solar mini grid makes much of a contribution toward poverty alleviation. Due to their higher tariffs, both of the solar energy technologies are used by rural middle-class people. In addition, limited hour energy backup and restricted number of appliances has made solar energy unsuitable for income generative activities. In practice, the solar home system is largely used for entertainment purpose (Jacobson, 2007). While the mini grid technology allows users access to a wide range of devices and longer duration of energy supply, it is very expensive for many islanders.

Needs are "neither necessities nor desire, in the modern development discourse need appears as a promise of development" (Illich, 1992: p. 90). The way development advocates characterise poor people's needs fails to acknowledge the heterogeneity of people's social development needs (Ferguson, 1994). For example, the way the need for education is perceived fails to take account of the spatially embedded, socio-cultural aspects of education. Having access to education and not being able to provide jobs in their own villages is a real challenge for many off-grid inhabitants. In this chapter we have seen similarities and differences in the experiences, perceptions, and realities of both male and female users of solar technology. Here I have emphasised the importance of a place-based understanding that conveys the complexity of class and gender roles associated with the use of energy technologies. For example, in rural Bangladesh traditionally a boy needs to learn education and training to become the future bread winner for a family, whereas as girl needs life skills to become a good housewife and a mother. Thus, this chapter has shown the intersectionality of gender, class, age, and geographical location and their importance in understanding the contribution of solar energy technology to rural development.

The impacts of various solar energy technologies transition in off-grid lives are usually positive. Solar electricity has created a sense of security, connectivity via lights, mobile phone and television. However, there is a distinctive difference between solar home system technology

and solar mini grid technology that reinforce the gender inequality in off-grid areas. The difference between the loud hubbub and bustling atmosphere of the bazaar, and the quiet, dimly-lit domestic interior space for women is enormous. Bright light and the capacity to run heavy-load machinery in the marketplace confirms the social hierarchy of men's and women's work and social construction. This chapter has argued that different forms of solar technologies not only reproduce stereotyped division of labour between men and women, but it also reinforces gender disparities in access to resources and services.

The contribution of this chapter to the thesis is that it has answered the question to what extent do solar energy interventions work to achieve particular goals of development (RQ 3). By showcasing off-grid areas users' voices, this chapter presents an analysis on the solar energy transitions and rural development. The chapter has contributed to the policy-related literature on experiences of small-scale electrification programmes in off-grid areas using specific context of solar energy technology. Not many policy studies have been conducted to evaluate electricity and the challenges encountered by women in terms of access, participation in decision-making, policy reforms, etc (Panjwani, 2005; Cecelski, 2005: Kohlin *et al.,* 2011: Oparaocha and Dutta, 2011), thus discussion on gender is a significant contribution to the energy literature. The following chapter discusses the integration of solar energy technology in urban areas.

Chapter Eight: Solar Energy on Urban Rooftop

Figure 8:1 Landscape of Dhaka city from a high-rise building. Source: Author

8.1 Introduction

How do people in on-grid areas integrate solar energy into their everyday lives? Why did the mandatory solar installation policy on urban rooftops last for such a short time? What experiences do solar energy users have in urban on-grid areas in Dhaka, the capital city of Bangladesh? This chapter is interested in answering these questions. Solar energy was introduced in on-grid areas in 2009 after the introduction of a policy that made solar energy provision a mandatory condition of access electricity connections for newly built high-rise buildings in major cities in Bangladesh. The policy required a newly built high-rise building to ensure that it had enough solar energy provision to generate and supply 3% of the total electricity consumption of that building. Having looked at the impact of solar energy transition on the energy market (Chapter Five) and impact on off-grid life in Sandwip (chapter Six), this chapter focuses on the experiences of the solar energy transition in on-grid areas in Bangladesh. The chapter investigates how people perceive the rooftop solar energy policy and what experiences the on-grid area residents had during the time in which the policy was implemented.

Energy provision, planning and policy have played a significant role in facilitating urban energy transitions towards sustainability lately. Much has written about the multiplicity and richness of climate change action in urban areas (Bulkeley and Betsill, 2005; Bulkeley and Castán-Broto, 2013; Castán-Broto and Bulkeley, 2013; UN-Habitat, 2011), but little attention has been paid to how these actions link to an urban energy transition (Bulkeley et al., 2014; Rutherford and Coutard, 2014; Seto et al., 2014). According to Castán-Broto (2017) hardly any literature has engaged with action plans for an urban energy transition, where city-specific conditions play a crucial role in urban sustainability trajectories. For here, from the regulatory context to the practices of energy use and the systems of provision in place, city specific conditions include both endogenous and exogenous factors. Similarly. Ruthford (2016) argues there is also a need to link this strategic, discursive level of infrastructure politics to more consideration of how energy becomes politicised on a more locally contingent, everyday level. Thus, this chapter explores the politics of urban energy transition from a more locally contingent and everyday level, using a city-specific experience of solar energy transition in on-grid areas of Dhaka, Using the specific examples of urban rooftop solar energy policy in on-grid areas I present the endogenous and exogenous factors of energy provision that have shaped the solar energy transition in on-grid areas in Bangladesh.

Here I agree with Rutherford and Jaglin (2015: 174) that a city's roles as context, constituent and consequence of the urban energy system continually changes and we need to understand the importance of space and the urban spatialities (Huber, 2015) revealed in this research.

This chapter is organised following ways: Section 8:2 investigates how people in Dhaka manage their daily life in everyday power disruption. Section 8:3 explores the emergence of solar energy policy on urban rooftops. Section 8:4 delivers how and why solar energy technology have struggled to create a space urban energy landscape. And finally, section 8:5 argues that the materiality of solar energy makes solar energy an invisible source of electricity which has a limited impact on everyday urban lives.

8.2 Load Shedding: an integral part of Dhaka city life

According to Trentmann (2009), disruption is normal in most systems all over the world (not just in the Global South) and reactions to them depend on the degree to which disruption is accepted as normal practice. However, power disruption or load shedding[48] has become an integral part of urban lives in Dhaka. The energy crisis has become one of Dhaka's most acute problems over the last decade as after rapid urbanisation the population of Dhaka alone consumes almost 41.22% of the total generated electricity (Reja and Shajahan, 2012). In 2009, load shedding was imposed for 351 days in Bangladesh, which varied up to 30.49% of maximum demand (BPDB Annual Report-2009). Due to the limited capacity of power generation and ever-increasing demand for electricity in both rural and urban areas, the Bangladesh Power Development Board (BPDB) has been unable to provide uninterrupted power supply to consumers. In addition, due to rapid urbanisation, the BPDB had to put new electricity connections for newly-expanded areas on hold for several years, creating enormous losses, not only for the real estate business, but also for city dwellers. As mentioned in chapter four, there is always a shortfall of supply relative to demand in Bangladesh, and constant power disruptions occur in the grid-connected areas. Especially during the summer season, people in on-grid areas endure 5-8 hours without electricity because of enormous demand, depending on location. Figure 8:2 is a cover page of a local magazine called Power & Energy published in May 2010. This feature explains how much emphasis the government places on mitigating the load shedding problem of Bangladesh.

[48] Load shedding is the deliberate shutdown of electricity power in a part of parts of a power distribution system, generally to prevent the failure of the entire system when the demand strains the capacity of the system.

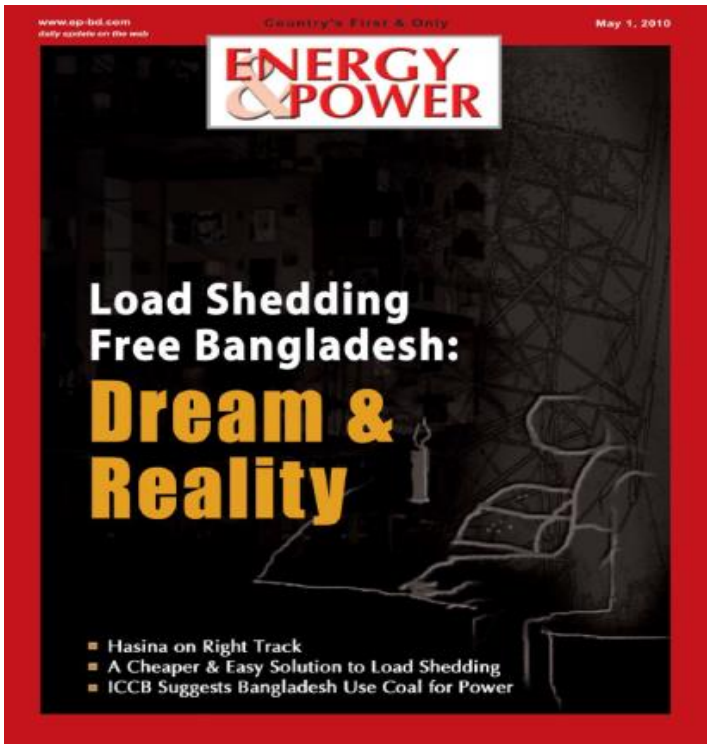


Figure 8:2 The front cover of the popular magazine Energy and Power published on 1 May 2010[49].

To cope with all these unceasing power problems, a number of technologies have been developed as a backup for power-supply issues over for the past two decades. The city dwellers who are connected to the grid maintain alternative sources of lights and electricity to deal with power disruption. The arrangement may vary depending on class, affordability, and availability of energy provision. These include candles, hurricane lamps, torches, rechargeable lights (which are popularly known as emergency lights or charge lights), rechargeable fans, and Instant Power Supply (IPS) and generators. In a middle-class neighbourhoods rechargeable lights, IPS and generators are the most widely-used technology. In contrast, candles, hurricane lamps and torches are popular among lower-income groups. While I was interviewing Kamal Uddin, a resident of Mirpur DOHS, he asked *"do I need to explain to you what load shedding is and how Bangladeshis cope with load shedding in their daily life? You have grown up seeing this problem, haven't you?"* Kamal Uddin is right: load shedding is not uncommon to me, I can write pages explaining everyday urban load shedding practices based on my experiences since childhood.

[49] Energy and Power published on 1 May 2010.

However, IPS has become increasingly prevalent in urban middle-class households over the last two decades[50]. An IPS stores power in its battery and supplies it during load shedding. However, one thing needs to be made clear: IPS is a solution for individual households, as with it they are able to save the electricity that they will need during the power outage. If we consider this practice in a wider context, this backup solution places an extra constraint on electricity demand. It is important to note that the main goal of power disruption via load shedding is to balance supply and demand. It also helps to cope with power shortages and distribute shortages more equally among different consumers in different areas. Thus, when the households own IPS and save electricity for power storage, it is essentially adding pressure to the supply. As a result, the practice of load shedding does not save electricity in the way it should.

Another popular alternative source of electricity is a generator. Lately, generators have become a popular means of power backup among urban middle and upper class residents who live in high-rise buildings. Since generators are expensive and physically quite large, it would be difficult for a single household to afford a large- capacity generator and keep it at home. In high-rise buildings, residents can afford to own a generator jointly, and at the end of the month they divide the cost equally among themselves like a 'service charge' or 'maintenance' for the buildings. This is commonly practised in cities as a form of private, informal initiative to cope with services disruption. These are the common technologies and devices used in urban middle-class neighbourhoods[51].

8.3 Emergence of rooftop solar energy in cities

In 2005, a pilot research project on-grid -connected roof-top solar was conducted by the Department of Applied Physics, Electronics and Communication Engineering at Dhaka University, with the financial support of the Ministry of Science, Information and Communication Technology. The project's findings suggested that PV was not viable and cost-effective in urban areas. According to the principal investigator of the project, Professor Rezaul Karim "producing per watt power through this system costs Tk 17, while the government sells power for household usage at between Tk 3 and 4 only. That is why this model is still not

[50] Price of IPS generally 12000-40000 taka ($140.97-$469.92) depending on the capacity of the system,

[51] Middle class is not explicitly categorized in economic statistics in Bangladesh, and it is mainly understood as a self-identified class identity that one usually carries as part of a family legacy (Karim, Shuchi 2012). The spectrum of income capacity within the middle class is wide, and one can position him/herself at different income points at different stages of life. Bangladesh defines an estimated 10 per cent of its population as middle class or as being in the middle income bracket; and any household within the income bracket of 10,000- 40,000 TK per month (Euro 97.09 – 388.375) can be termed as middle class. For Seuty Sabur (2010), the middle class is a group of individuals with certain levels of education, engaged in specific professions, sharing a set of core values, and who have a sense of security and stability.

feasible" ('Harnessing solar energy for supply to grid' reported in The Daily Star 20-05-2007). Safiqul Islam, an academic who works as a consultant for multiple government energy projects, and who was also involved in the pilot project, confirmed to me "*we never suggested this policy for urban rooftops; it was never a practical choice for urban consumers from the technical point of view".* Therefore, it is worth exploring why and how solar energy emerged as a policy solution in urban settings despite experts' non-recommendation of this technology.

A mixed and controversial range of opinions was found about the emergence of this policy in cities in Bangladesh. I was curious to know how solar energy emerges and was chosen as an alternative technology for urban electricity crisis. The emergence of solar energy in urban areas is a cumulative effect (Wihlborg and Palm, 2008) of many actors. Chief among these actors, who are concerned with bringing solar energy into the electricity network, is the current government who needs to fulfil its electoral promise of solving the electricity problem in Bangladesh. The rooftop solar energy policy appears to have been driven by political pressure from the private sector which wants to create a solar energy market in Bangladesh. In particular, some of the respondents believe that a solar energy policy was introduced after intensive lobbying by solar battery manufacturers. For example, a real estate developer, Mahmudul Haque, claimed that

"*the current government was under enormous pressure from battery manufacturers to draw up a policy which would allow them to sell batteries in urban areas". He also claimed that "the best way for increasing battery sales is having solar energy in urban buildings; and people will buy it if it is mandatory". I heard this argument several times during the fieldwork, an argument which mostly came from real estate companies*.

Mahmudul Haque says*:*

"we tried our best to convince the Ministry of Energy not to push forward the policy as the current system power supply system is not suitable for solar technology in urban areas like Dhaka, Chittagong or any other major city, but they completely ignored our opinion and experts' concerns." When asked why the government neglected his and other experts' input, he replied: "I think battery manufacturers are more powerful than us, that's why they made the government go for this policy".

Mahmudul Haque's comments reveal the tension between different actors who are involved in the Bangladeshi energy sector. Other developers have different views. For example, Rafiqul Islam Chowdhury, the manager of the Arman Developer Company, states that "pressure on the government from different entities…NGOs who generally work in rural off-grid areas, want to expand their work in urban areas; battery companies who want to grab business in urban

areas forced the government to have this mandatory policy of solar energy". Chowdhury adds that high-rise dwellers have been buying generators for load shedding[52] back up and IPS businesses have been affected by this. Therefore, the IPS and battery manufacturers wanted to get their market back by enforcing photovoltaic solar energy in on-grid areas". While the above-mentioned concern from the real estate developers in Dhaka varies from one to another, the comments reveal that emergence of solar energy is a political consequence of many actors who want to earn money from this emerging sector.

Globally there has been a positive trend in planning urban spaces to develop 'green' infrastructures. A number of cities now aspire to the title "solar city" by using a variety of strategies to advance solar power and renewable energy (Beatley, 2007). Sharing this aspiration, the government of Bangladesh aims to generate 10% of the total electricity supply from renewable energy by 2021; and bringing solar energy to on-grid areas is also part of this target. To achieve this a number of solar energy systems have been installed in various government offices such as a 21.16 KW solar PV system at the Office of the Prime Minister in December 2009 and a 20 KW solar PV system on Bangladesh Bank (BB) in October 2011. The idea behind this installation was to encourage city dwellers to produce their own electricity from their own rooftops. It was believed that solar energy from building tops could help significantly in ensuring an uninterrupted supply of electricity which would greatly mitigate the prevailing energy crisis. It was estimated that high rise buildings could install solar energy and produce approximately 300 megawatts of electricity from some 20,000 multi-storeyed buildings in Dhaka.

Agreeing with Luque-Ayala, (2012), I argue that urban problems are constructed from a multiplicity of different and dispersed statements, sites and viewpoints. Here I argue we need to understand 'the conditions under which the problems emerge, continue to operate, and are transformed' (Dean, 2010) by examining the way in which the urban crisis is problematized in the city. In Dhaka, the discourse of electricity crisis and the emergence of an urban solar energy policy are strongly connected. Currently, there are 600 members in REHAB Bangladesh (Bony & Rahman, 2014), who build more than 1500 new high-rise buildings every year. This rapid and ever-increasing urban expansion has an impact on services such as the water supply, electricity supply, gas supply, sewage system and other urban infrastructure. To cope up with the urgent electricity problem, in 2009 the Ministry of Power, Energy and Mineral Resources decided to push forward a renewable energy policy and prepared a new building

[52] Load shedding: an act or practice of the deliberate shutdown of electric power in a part or parts of a power distribution system to prevent the failure of the entire system when the demand strains the capacity of the system.

code with a mandatory provision for the installation of solar panels on the rooftops from the following year. According to the policy, a residential consumer who wanted to have an electricity connection with more than 2 kilowatts of load, had to set up a rooftop solar panel covering at least 3 percent of the total sanctioned load. For industrial and commercial consumers, 5 percent of the total light and fan loads had to come from rooftop solar panels.

By talking to different respondents who live in Dhaka, it became clear that the solar energy policy for urban rooftops was not welcomed by the majority of the high-rise building dwellers. Most expressed their dissatisfaction with the unclear objectives of the policy. This fieldwork took place a few years after the Prime Minister's Office and Bangladesh Bank had installed their solar panels. However, it was rumoured that due to lack of maintenance these PV systems had stopped working. Asaduzzaman, one of the staffs at Ashrafi Enterprise told me

"*if you go to the PM's office, you will find the solar panel is not working, and that a huge amount of money has been wasted*".

A similar comment was made by another respondent about solar streetlights. Several solar panels were also installed in Matijeel and New Market areas between 2009-2010. According to Asaduzzaman the solar streetlights for worked only a few months after the installation. Although the government tried to justify the urban solar initiative on several occasions through the news and other media outlets, consumers remained unconvinced. There was no dialogue between general consumers and the Bangladesh Power Development Board (BPDB). Many high-rise building dwellers talked about restrictions on personal freedom.

According to Shahriar Mustafa, a flat owner in the Bashundhara area,

"I cannot justify this solar energy policy for high-rise dwellers… an official from the Power Development Board stated in a press conference, 'we are not asking poor people to buy this solar panel, the people who live in the high-rise are well off and they have the ability to buy this', I think this is unfair on us."

Shahriar Mustafa, a flat owner who lives in the Bashundhara residential area shared his views on this matter.

"*Why should a flat owner take on this burden, if the government can't provide electricity for everyone? I have been saving up my entire life to buy a flat; why would I pay extra for these services? Is it not the government's responsibility to ensure electricity for everyone? It seems like it is our responsibility to have money, to afford to buy a flat; and then spend money on the state's inability*!"

Nazifa Khanam, another flat owner says

"I can't justify this kind of unsuccessful project by our government. Without any proper planning, all of sudden they take a random project, and after a few months or years, it results in nothing. We pay tax for our country's welfare, and look at how they are wasting our money".

The concerns of flat owners like Shahriar and Nazifa opens up questions of how new energy provision affects particular collective and individual values and the responses and engagements of various 'publics' with energy infrastructure (Walker and Cass, 2007; Cotton and Devine-Wright, 2012). Clearly neither the solar energy policy, nor the government's initiative of installing solar PV on government offices was seen to have brought any positive impacts to the flat owners that I interviewed. In the following section, I investigate in detail the reasons why solar energy policy failed in on-grid areas.

8.4 The struggle to create a space for solar technology in on-grid areas

In this section I explore the struggle for solar technology to be integrated as an alternative source of electricity in on-grid areas in Bangladesh. A number of economic, socio-technical were identified during the fieldwork. The following section explores the key barriers of solar energy transition in on-grid areas in Bangladesh.

8.4.1 Economic Barrier: High Price

The high cost of solar energy technology is considered one of the key barriers for solar energy dissemination in developing countries (Eric Martinot, 2001). It is said that the price of solar energy has been gradually reduced over the period (Laidi, Abbad, Berdja, & Chikh, 2012), but it is yet to come into the range of the general public (Dewari, 2012). In chapter five we have seen, having identified this important barrier, several financial measures have been put into place over the period. However, in the case of urban solar dissemination, neither the government, nor the international donor organisations provided any financial support to reduce the price of solar energy. Besides, the cost of solar electricity is much higher than electricity from any other generation sources. In the survey, Dewari (2012) shows the cost of electricity generation in Bangladesh, highlighting the high cost of solar electricity with a battery (50.74 tk/Kwh) compared to other sources.

Table 8:1 Tariff of electricity from various energy sources.

Fuel Source	Tk/Kwh
Hydro	1.4 ($0.016)
Coal (local)	3.7 ($0.043)
Gas	4.2 ($0.049)
Coal imported	5.4 ($0.063)
Heavy fuel oil	12.1 ($12.1)
Diesel	25.2 ($0.30)
Solar with battery	50.74 ($0.60)

Source: Dewari, 2012

Table 8:1 demonstrates the tariff of electricity from various energy sources. Hydro, coal and gas tariffs are below 5 tk KwH, whereas electricity from imported oil is less than half the tariff cost of solar electricity. Here, it is worth mentioning energy subsidies are relatively high in Bangladesh, with most retail prices for fuel and electricity set at lower than their actual market prices. There are two types of electricity subsidies in Bangladesh: one type of subsidy lowers production costs through subsidised fuel (e.g. natural gas, coal, diesel, furnace oil, etc.) in electricity generation; the other type offers electricity tariffs for groups of consumers (including residential customers and farmers) that are lower than production costs. It should be noted that the electricity tariff structures in Bangladesh differ across sectors and levels of consumption. Industrial and service sectors pay higher tariffs while domestic and agriculture sectors pay lower, subsidised tariffs (Mujeri et al. 2014). Thus, the domestic sector is partially cross-subsidised by the industrial and commercial sectors. It is argued that as a result of the high subsidy and its cross-sectoral nature, the Bangladesh Power Development Board (BPDB), which generates around 60% of the country's total electricity, has consistently incurred losses by selling electricity at prices lower than the break-even point.

The price of solar electricity is expensive (see table 8:1), there has been no initiative from the government to reduce the price. As we have seen in previous chapters that to make solar energy technology financial accessible, various financial mechanisms have been introduced by donor organisations where IDCOL as a mediator on behalf of state support PO/NGOs to sell the solar energy product on credit. However, no financial support had been given to reduce the price. Thus, when a customer compares the tariff of solar electricity with grid electricity provided by BPDB, they have little interest in buying solar PV for generating electricity because of the cost.

8.4.2 Technological barrier

Some respondents believe that the nature of solar energy technology is not appropriate if it is not connected to appropriate technology. Two types of solar PV systems are used in high-rise buildings: Grid-tied and off-grid. Grid-tied is A PV system connected to the utility grid and off-grid is a system which is connected to a solar battery instead of grid. If a building installs a grid-tied system, this system can only be used in the daytime because without storage facilities the system will not able to supply electricity at night. In contrast, the off-grid system comes with a set of batteries able to store electricity and allows the users to use the electricity whenever they want. Off-grid systems are more expensive than grid-tied systems, thus many high-rise buildings chose grid-tied systems to reduce the cost of initial installation. While the off-grid system helps the high-rise dwellers to reduce the price, it also creates several technical difficulties in utilising the technology in the most efficient way.

The first technical problem that installers of solar energy systems face is finding an appropriate connection to get the most benefit from high-rise buildings. As a grid-tied solar technology system can only be used in the daytime, the primary challenge for a grid-tied solar energy system is to find a connection that would be most functional during the daytime. However, during the daytime most households do not need to use lighting if they are busy outside the home. One could argue that, apart from lighting, there are many, other daytime uses for solar energy in a multi-storeyed building: it could, for example, power an elevator or a water pump and other electricity connections. According to a construction site engineer, Habibul Bashar:

"*there are also some risks involved with other connections if the output of solar energy fluctuates. Solar panels always need sunlight evenly; sometimes a passing cloud could have an effect on the flow of electricity generation that might involve risk if we connect a heavy load to run a lift or a water pump*".

A large load entity can balance the inherent fluctuations of a solar output by accessing other power plants; but an average household might have difficulty in balancing sudden fluctuations during the day. Home use of solar output is, therefore, routed through a battery, which ensures a steady flow. Most home appliances don't have the ability to tackle frequent electricity fluctuations (Dewari, 2012). Therefore, electricity from solar may not be reliable and appropriate for a connection like an elevator or other big machinery.

Among the people I interviewed in Dhaka, no one denies the positive features of solar energy, nor the novel intention to use solar energy in the city. Theoretically, maximum use of solar energy would help minimise additional demands on the national grid. However, the problem of identifying an appropriate connection to use electricity generated during the day left much solar generation unused. From the previous section, it is clear that, to maximise solar energy use, batteries can play a major role as they store electricity to be then used at the time in which it is convenient. But due to the higher cost many flat owners are reluctant to buy off-grid systems.

8.4.3 Spatial Barrier: Finding an appropriate place to install the panels

While solar energy emerged in on-grid areas to solve the electricity problem in Bangladesh, the rooftop of a high-rise building was considered the most appropriate space to use. Here I argue that by choosing the high-rise rooftop for solar energy installation, this policy has overlooked the importance of rooftops in the urban life in Dhaka. 'Politics of the urban living space'' Jonas et al., 2011, p. 2548) are as important as socio-technical barriers. Rooftops can be underutilized components of urban landscapes in many countries (Byrne, Taminiau, Kurdgelashvili, & Kim, 2015). In Bangladesh, however, culturally, an urban roof is not an underutilised space. Houses built from bricks generally have flat roofs which have multiple uses. For example, roofs are used as a garden, a playground, a place of social interaction, celebration, etc. Whyte (1980) believes urban spaces small or big have a social life: here in this section, I argue that roofs in cities have a social life that has always been important in city life in Bangladesh. With extensive urbanisation and overpopulation in the main cities, spaces around many neighbourhoods have been shrinking, and there is hardly any empty space to use as a playground or for social communication. Therefore, in high-rise buildings, the rooftop is an important site for many flat dwellers.

During the fieldwork I learned that high-rise building residents use the roof for multiple purposes in their everyday life. Figure 8:3 shows multiple aspects of a roof's social life in Dhaka: socialisation, playing ground and gardening, drying clothes, morning/evening walks and much more.

Figure 8:3 Social life of roofs in Dhaka. Source: Author

Hasina Akhter, a high-rise dweller in the Bashudhara residential area talks about why having an open rooftop is important in her family's day to day life:

"Our apartment is located in a busy area, it is not really a residential area: the street in front of our house is always busy. Both of us (her husband and herself) have a diabetic problem. We need to walk to have control over our sugar level. There isn't any park near our apartment. In Dhaka you will hardly find a proper park where people can walk, run or do exercise. So people our age, we use the rooftop to walk as exercise".

Similarly, Rabiul Chowdhury denotes "*most of the roofs in Dhaka city have different purposes: in our flat, half of the roof is used as a community centre where the apartment owners use the space for social gatherings or other family events. The remaining half of the roof is used for drying clothes or other household related work. There is no breathing space in Dhaka: if it is blocked with solar panels, people would have nowhere to go*".

Figure 8:4 Solar panels on water tanks Source: Author

Therefore, to occupy the rooftops with solar panels is not socially or practically viable for the residents. In consideration of the multiple uses of a rooftop, the rooftop solar policy recommended keeping at least 20 square feet of the area on the rooftop free for various uses (Energy & Power, 2011). Yet it was not practical, hence the only place left to install solar panels was the space above the rooftop. After ‘‘the practical negotiation” (Hubbard, 2006, p. 96) with the city life solar panels find a place on the water tank. From the figure 8:4 it is obvious that in this small allocated space an insignificant amount of electricity can be produced which has hardly any influence on urban day to day life

8.5 Invisible existence of solar technology in on-grid areas

The invisibility of solar technology in on-grid areas makes solar technology unessential for city life. Although physically, solar technology consists of visible equipment, a number of reasons have made solar technology invisible in Dhaka. These are on-site inception, insignificant outcome, a strong presence of other sources of electricity as backup, and the nature and material capacity of solar technology which are interconnected with each other. In what follows, these concepts are explored individually.

The first reason for solar technology being invisible is the time and process of on-site inception in a high-rise building. By on-site inception I mean the time and process of solar energy arrival in a high-rise building. Here I argue that, since solar technology systems enter high-rise buildings before the residents, the existence of solar energy becomes imperceptible. Before explaining the process of assembling solar energy on high-rise rooftops, we need first to

understand the process of acquiring an electricity connection in a newly built apartment. When a new building contract commences, the builder or locally known developer needs a temporary power connection to carry out the construction work. The temporary connection is given to the contract site with a commercial tariff. When the construction is nearly finished, the developer applies for a permanent electricity connection for the residents or users. Tariffs for domestic customers are lower than for commercial buildings. Usually, a real estate developer needs to submit an electricity consumption plan and a layout of electricity consumption six months beforehand when applying for an electricity connection.

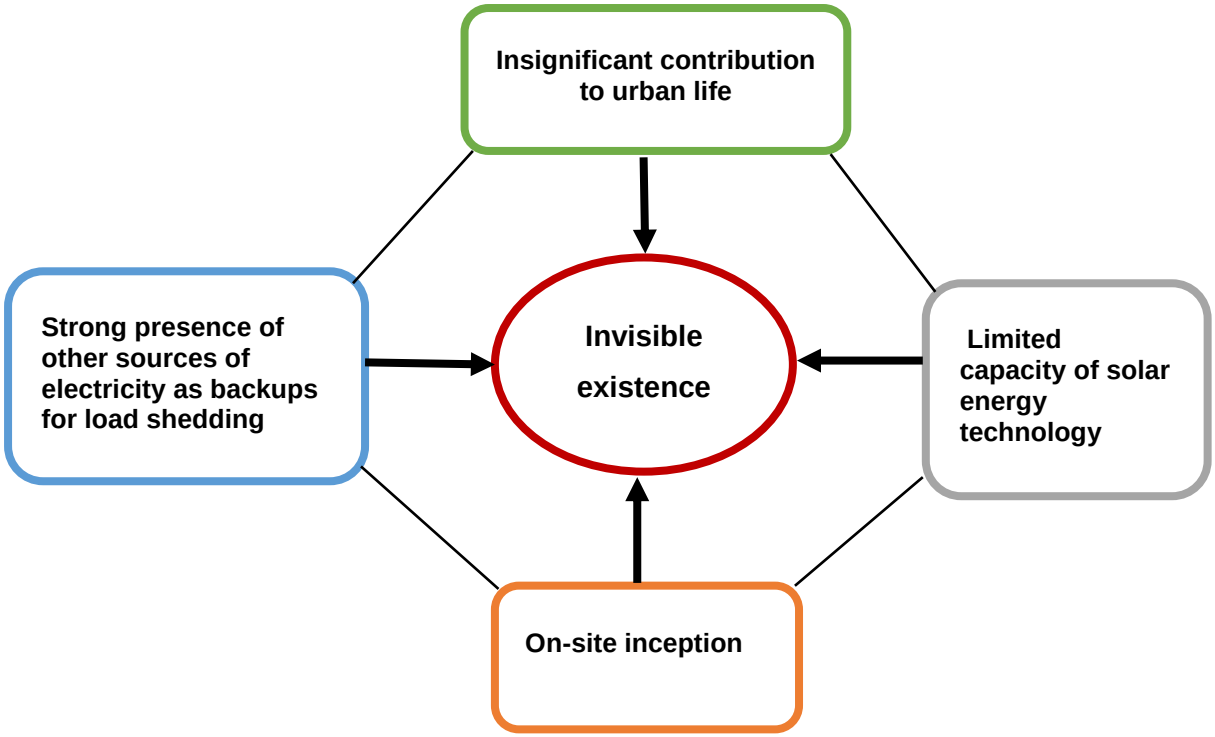
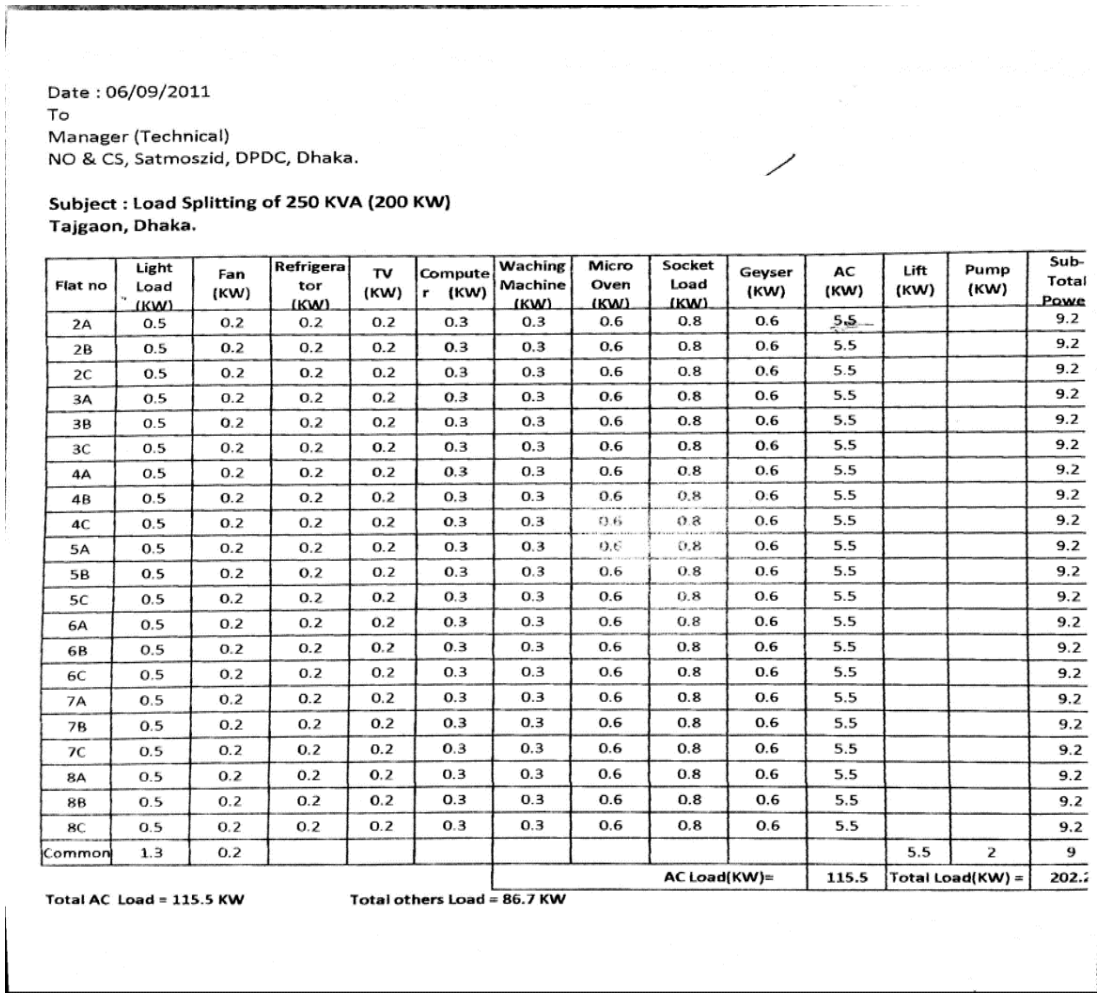


Figure 8:5 Invisible existence of solar energy in high-rise building. Designed by Author.

Table 8:9 below is a sample of the consumption plan of a high-rise building. With the detailed information of possible electricity consumption, the developer submits an application for an electricity connection. Once the request is placed to the division office of Dhaka Power Distribution Company (DPDC), DPDC informs the developer whether they need to install a solar energy system, and its capacity. After the installation of the required solar energy system, an inspection takes place, and, if the inspector is satisfied, then the DPDC allocates a permanent electricity connection for the new building. It is important to mention that the developers need to sign an agreement that no air conditioning will be installed in this building. However, a majority of the high-rise buildings, especially in upper middle-class

neighbourhoods, use at least one air conditioner. Although the developer signs an agreement to not include air conditioning provision, in practice, it is an open secret that a large portion of residents in high rise buildings, side-step the restriction



Date : 06/09/2011
To
Manager (Technical)
NO & CS, Satmoszid, DPDC, Dhaka.

Subject : Load Splitting of 250 KVA (200 KW)
Tajgaon, Dhaka.

Flat no	Light Load (KW)	Fan (KW)	Refrigerator (KW)	TV (KW)	Computer (KW)	Waching Machine (KW)	Micro Oven (KW)	Socket Load (KW)	Geyser (KW)	AC (KW)	Lift (KW)	Pump (KW)	Sub-Total Powe
2A	0.5	0.2	0.2	0.2	0.3	0.3	0.6	0.8	0.6	5.5			9.2
2B	0.5	0.2	0.2	0.2	0.3	0.3	0.6	0.8	0.6	5.5			9.2
2C	0.5	0.2	0.2	0.2	0.3	0.3	0.6	0.8	0.6	5.5			9.2
3A	0.5	0.2	0.2	0.2	0.3	0.3	0.6	0.8	0.6	5.5			9.2
3B	0.5	0.2	0.2	0.2	0.3	0.3	0.6	0.8	0.6	5.5			9.2
3C	0.5	0.2	0.2	0.2	0.3	0.3	0.6	0.8	0.6	5.5			9.2
4A	0.5	0.2	0.2	0.2	0.3	0.3	0.6	0.8	0.6	5.5			9.2
4B	0.5	0.2	0.2	0.2	0.3	0.3	0.6	0.8	0.6	5.5			9.2
4C	0.5	0.2	0.2	0.2	0.3	0.3	0.6	0.8	0.6	5.5			9.2
5A	0.5	0.2	0.2	0.2	0.3	0.3	0.6	0.8	0.6	5.5			9.2
5B	0.5	0.2	0.2	0.2	0.3	0.3	0.6	0.8	0.6	5.5			9.2
5C	0.5	0.2	0.2	0.2	0.3	0.3	0.6	0.8	0.6	5.5			9.2
6A	0.5	0.2	0.2	0.2	0.3	0.3	0.6	0.8	0.6	5.5			9.2
6B	0.5	0.2	0.2	0.2	0.3	0.3	0.6	0.8	0.6	5.5			9.2
6C	0.5	0.2	0.2	0.2	0.3	0.3	0.6	0.8	0.6	5.5			9.2
7A	0.5	0.2	0.2	0.2	0.3	0.3	0.6	0.8	0.6	5.5			9.2
7B	0.5	0.2	0.2	0.2	0.3	0.3	0.6	0.8	0.6	5.5			9.2
7C	0.5	0.2	0.2	0.2	0.3	0.3	0.6	0.8	0.6	5.5			9.2
8A	0.5	0.2	0.2	0.2	0.3	0.3	0.6	0.8	0.6	5.5			9.2
8B	0.5	0.2	0.2	0.2	0.3	0.3	0.6	0.8	0.6	5.5			9.2
8C	0.5	0.2	0.2	0.2	0.3	0.3	0.6	0.8	0.6	5.5			9.2
Common	1.3	0.2									5.5	2	9
								AC Load(KW)=		115.5	Total Load(KW) =		202.2

Total AC Load = 115.5 KW Total others Load = 86.7 KW

.

Figure 8:6 An example of a complete plan for electricity use in a new high-rise building submitted by a developer applying for a new electricity connection. Source: collected by the author.

During the research it became clear that people thought that bad practice was rife in not only the solar energy sector but the entire power sector. An interview with Md. Qazi Ahmed, the procurement of officer works leading real estate companies in Dhaka, gave me an insight into the relationship between service organisations and their customers. Qazi was very open and, without any hesitation, he told me that *"everyone in the power sector is corrupt: from clerks to the top boss, not a single paper moves from one desk to another without any bribery".* I asked Qazi to elaborate, upon which he replied: "*Trust me, as a procurement officer, I deal with all the utility companies, on behalf of our company. But I would say that the power sector is the most corrupt sector. It is true that due to solar energy the corruption has increased, but the*

sector was already corrupt". He has been working in this industry for the last seven years since he graduated. The claim that Qazi made is the same one I heard from other respondents. Some literature cites the corruption and inefficiency of the power sector as the main reason for the power crisis and failure of this sector (Ahmed 2011) discussion in the Chapter Four.

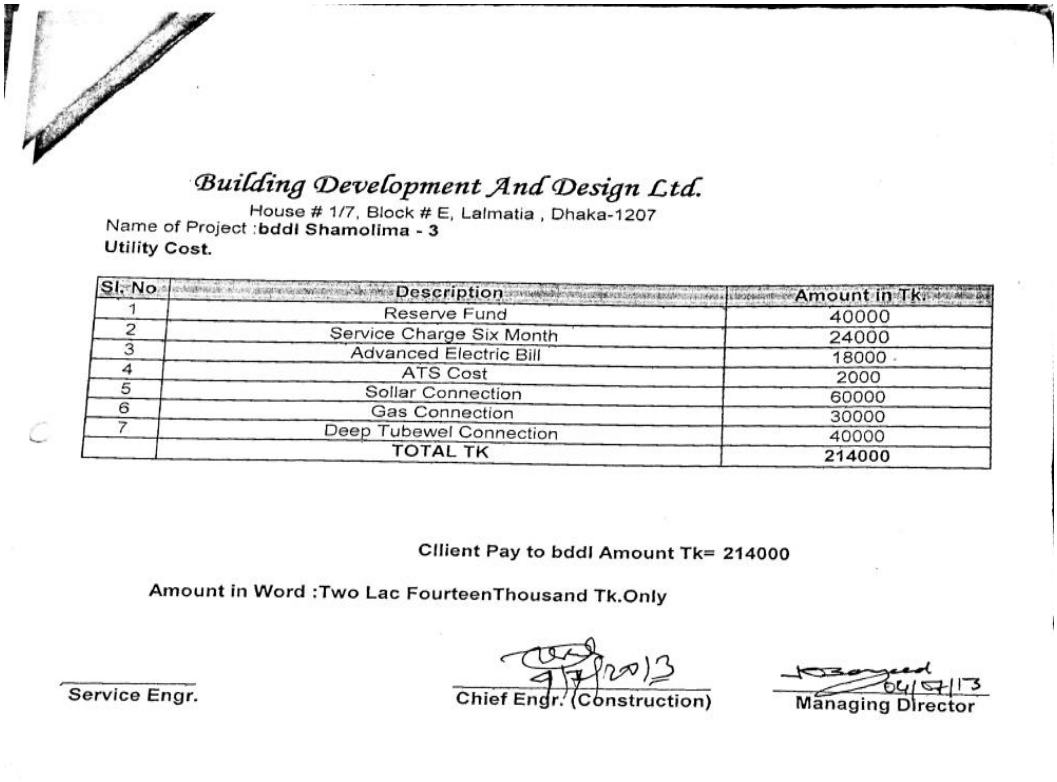
Qazi admits "*we build a number of buildings in a year, and sometimes they have some flaws in the construction: for instance, a utility room which is too small, stairs which are too narrow, not enough space for parking, etc. Sometimes we do it to make more profit: if we make the utility room small then we can get some space for an extra parking area. When the inspection takes place, the inspector can identify these drawbacks easily. Most of the time, the inspector from the utility company takes advantage of the flaws that we created. To provide a satisfactory certificate, they demand a bribe and we need to fulfil their demand*".

Raihana "*You said they are taking advantage of faults in the construction; but if a building is constructed without any major flaws, will they still be bribed?"*

Qazi *"no matter how perfect the construction is, if the inspector is corrupt, we need to pay a bribe to get the certificate". He adds that "everyone knows that people in a high-rise building can afford aircon and that we provide aircon connection. But as a part of the new policy, we sign an agreement stating that the building will not use any air conditioning. The load that we ask from PDB does not include the load required for an air-conditioner. But in reality, the building might consume more electricity than it asked for. If we do not accept their demand, they might come back and create complications for the flat owners or residents. So, we have no other option but to accept their demand".*

The whole conversation with Qazi was insightful and eye opening. Although Md. Qazi is blaming the power sector for the corruption, the conversation also confirms the shortcomings of the real estate industry.

Coming back to the installation process, once the inspector is satisfied, permission is granted for an electricity connection on the condition that a solar energy system of a particular size is installed. After receiving the specifications, the developer gets in touch with the solar energy installer company to install a solar energy system. Once the system is installed, the inspector comes to conduct another inspection and gives permission for the permanent electricity connection. The cost of the solar panel is borne by the flat owners. Thus, it adds an extra charge to their apartment cost. A sample copy of the utility bill is provided below, showing that for a solar connection a household needs to spend 60,000tk additional to other utility costs.



Building Development And Design Ltd.

House # 1/7, Block # E, Lalmatia , Dhaka-1207

Name of Project :**bddl Shamolima - 3**

Utility Cost.

Sl. No	Description	Amount in Tk.
1	Reserve Fund	40000
2	Service Charge Six Month	24000
3	Advanced Electric Bill	18000
4	ATS Cost	2000
5	Sollar Connection	60000
6	Gas Connection	30000
7	Deep Tubewel Connection	40000
	TOTAL TK	214000

Cllient Pay to bddl Amount Tk= 214000

Amount in Word :Two Lac FourteenThousand Tk.Only

Service Engr.

Chief Engr. (Construction)

Managing Director

Figure 8:7 Cost break down of utilities Source: Collected by author.

Sometimes the cost of solar installation is included with the electricity connection cost, meaning that the clients do not a have clear idea of how much money they are spending on the solar energy system. In table 8:10 we can see that the developer charged a flat owner 60,000 tk, but there is not any breakdown of the costs incurred or the solar panel or battery. Many respondents admitted that they do not know how much they had paid for solar because it was not stated clearly within their utility connection invoice. A. Rahman, an engineer for a real estate company, admits: *"actually our clients don't get actual information on how much money we spent for solar; usually the developer charges more money that we spend".* Since the installation process is entirely arranged by the developer, the actual price of solar remains unknown to the flat owners. Therefore, the solar installation process remains a mystery to them. The residents are unaware of the entire system, for instance who installed the system, what the agreement with the seller is, what brand was used, how long the warranty period is, etc. Mirza Rasheduzzaman, a flat owner in Uttara Model Town, believes if the flat owners were involved with the solar technology system buying process, people would have been more involved with the technology.

Raihana "*Why do you think so*?"

Mirza "*If we, I mean the flat owners, were buying the solar technology system, we would have definitely chosen a good reputable company. We would have gone to different places to compare the products, market and services*.

Raihana *"Do you think it would have made a big difference, compared to the product and service you have now?"*

Mirza "*Of course, why not! When the developer selects the product, their main motto is to save money, they would hardly think about durability because it is not their money, it is our money. But when a flat owner selects a product, s/he would choose the best quality product because they are spending a lot of money on it. I am sure if the flat owners were involved with the installation process, people would be more invested and would take the technology seriously"*.

Raihana "*I can understand your point that the owner would choose the best quality, but why do you think that if people were involved, they would take it seriously*?"

Mirza "*It is very simple: if you are going to get the benefit from a product or technology, wouldn't you pay more attention? When you choose the best product, you will get the best service, right? When you are involved in the process of buying, you know all the terms and condition of the technology, as well as the services. What is happening now is that the flat owners or tenants who are not involved with the process have no idea of the system. So, when a problem occurs, no one knows who to go to, or how to solve the problem"*.

From the above conversation, it is clear that the residents of high-rise buildings are not satisfied with the quality of the product. The conversation also demonstrates that there is an issue of mistrust with the choice of the real estate developers. Additionally, limited knowledge of the solar technology services makes the technology unpopular. Solar energy policy on urban rooftops is fragmented. While bringing low carbon energy in on-grid was a novel idea from environmental perspective, from a policy perspective there were gaps in the implementation and monitoring and evaluation.

8.5.1 Insignificant contribution in daily life

Samawat "*Solar is a loss project, a few months ago REHAB did an evaluation research, it is a total loss project"*

Raihana "*why you are calling this a loss project"?*

Samawat "*because the solar output is zero. People are not getting any benefit from solar* "

Raihana "But why do you think people are not getting any benefit? Every month thousands of solar energy systems are being sold…"

Samawat *"we need to think about what kind of benefits a solar technology system provides. Ok…think about what people can run using solar energy: a few lights or a couple of fans. In contrast, IPS can run almost everything in your house. Why would people get a solar technology system instead of using IPS? For an IPS you will spend 25 to 40 thousand, whereas for solar we charge them 50 to 70 thousand. 50 thousand for a light or fan, unacceptable!"*

This was a conversation with Samawat Hossain, procurement manager of East West Properties. My conversation with both solar energy providers and developers revealed that the reason solar energy fails to attract high-rise dwellers is because it makes an insignificant contribution to users' day to day lives. Some of the respondents believe that if people were gaining moderate benefits from solar energy systems, the acceptance of solar energy in on-grid areas may have increased.

Amena Mohsin, a flat owner in Uttara, states: "*after spending 50,000 taka, if I only get a light bulb connection and just for day time use, how could I get benefit from this system… I hardly get chance to use it*"

Raihana "*why do not you use it, you have spent money on it*?"

Amena"*n apartment buildings we don't need to use the solar as we have other sources of electricity…we have our backup for load shedding. Solar may be good for rural areas where people do not have access to electricity, but here in city we have electricity, we have generators, we have IPS, we have everything*".

Hypothetically, solar energy technology is a backup electricity supply in on-grid areas when load shedding occurs. In theory solar technology stands as complementary to other established backup sources like IPS and diesel generators, but in practice "nobody considers solar technology as a reliable backup" according to many respondents. According to Abdul Hamid, an engineer in a solar installation company, *"although on paper we show solar energy as the third or fourth backup, in practice, nobody considers solar as a backup; it is rather a complementary source of electricity".* Technically, solar energy does not operate as an appropriate substitute in many high-rise buildings. This is because the majority of electronic appliances require a solar technology system with huge capacity. Solar energy is also

considered less reliable by users, as well as providers, since the performance of solar technology is based on sunlight. Thus, a solar energy connection is used in the spaces of high-rise buildings which are considered least important: for instance, parking spaces, drivers' rest rooms, domestic workers' quarters, stair lighting and utility rooms. If a solar energy connection is provided to the inside of flats, each household gets a connection and this connection is used mostly in domestic workers' room, storerooms, verandas or any rooms considered as the least important by the family.

Similarly, to the previous reason, a strong presence of other sources of electricity positions solar technology as undesirable and unwanted. Due to the insignificant contribution of solar technology in everyday use, its existence does not feature in people's everyday lives. The way solar technology was developed along with other electricity backup lines means that, in many cases, no one notices if it does not work.

"*I know our staircases' lights are connected to solar, but I am not sure if it is now running from solar electricity or actual grid electricity. I think we won't be able to tell if solar technology is not working or not. If it doesn't work, the staircase' lights will be run by grid electricity, if the grid electricity doesn't work due to load shedding, they will be run by generator*" says Tahmina, a flat owner of Mohammadour

Thus, limited dependency on solar technology and high reliance on other electricity sources keeps the existence of the solar technology system invisible. This section argues that if the presence of other electricity sources were not strong and reliable, solar technology would have succeeded in gaining importance. While technical difficulties have been responsible for making solar energy unpopular, the material capacity of solar technology has also made flat owners unenthusiastic about making the most out of it. My research data demonstrates solar energy transition in on-grid areas is shaped not only by technical aspects, it is also co-produced through the interrelation of their social and material elements, as Bulkeley & Castán-Broto (2012) claim in their research. Thus, this section argues the material elements of solar energy technology makes invisible in urban everyday life the way solar technology is configured in urban landscape.

8.5.2 Lack of maintenance and after-sales services

Many argue that 'dominant concerns tend to be with the spectacular collapse of whole cities, societies or civilizations, rather than the mundane interruptions and repairs that constitute the quotidian existence of urban dwellers' (see Schneider and Susser, 2003; Vale and Campanella, 2005). Regular cleaning solar panels every fortnight or every month improves

performance. However, due to a non-accessible location, routine cleaning is often forgotten or ignored (Figure 8:11). In the picture (Figure 8:11) it is clear that the location of the solar panels makes them difficult to access. Furthermore, when it comes to the question of who is responsible for cleaning the panel and performing regular maintenance, this leads to another problem: high-rise buildings in Dhaka comprise many flats and thus many flat owners; therefore, who takes responsibility for routine rooftop maintenance is contested. To minimise conflict, this kind of communal responsibility, such as cleaning or maintenance, should go to a caretaker or a manager[53]. Generally, caretakers of high-rise buildings have limited knowledge of technology: to understand technical problems of a solar technology system, the person needs to have had technical training to identify a problem in the solar technology system.

Maintenance and servicing are an integral part of any technology. Graham and Thrift (2007) argue that 'many sophisticated commodities are made to be replaced and disposed of through accelerating cycles of acquisition and almost immediate disposal'. Besides, maintenance activities are also important so that both commodity production and waste can be minimized (Verbeek, 2004). Nonetheless, lack of after-sales services is another problem for the sustainability of this technology. Fieldwork data reveals that repair and after-sales services for solar technology maintenance in on-grid areas is yet to gain consideration. Here, I argue that as solar technology makes an insignificant contribution toward the everyday life of high-rise residents, mundane interruptions only affect a minor part of the city. Thus, activities of maintenance and repair of solar technology are neglected. I met a number of apartment dwellers claiming that they used to use solar when they moved in, but once there was an issue with technical maintenance, they stopped using it.

[53] It is a common practice for flat owners in high-rise buildings in middle class neighbourhoods to appoint a caretaker to look after day-to-day issues such as cleaning the common spaces, staircases, parking areas and garden,and arranging repair services if anything goes wrong

Figure 8:8 Solar panels on rooftops

The problem has a direct connection to the on-site inception of solar panels I discussed earlier (section 8.5). Since the solar system is installed by the developer, once the building has been handed over to the flat owners, no one knows the exact details of the solar installer company, nor the system's terms and conditions. I visited an apartment in Uttara Model Town where the residents had moved in two years previously in 2009. It was a newly-built six storey apartment with a solar technology system on the roof. The residents told me their stair lights used to have a connection with solar energy, but no longer use solar. Mahdin Faria, a resident of Dreamland Apartment, says "*we used solar light for six months, and then there was a technical problem with the system. My husband and a few neighbours wanted to arrange a repair service so that*

we could continue to use it, but when they went to the company that installed the solar system, they refused to admit they had installed the system in our flat. So, we tried to contact other companies to arrange servicing, but we couldn't do it. Since then we haven't used solar lighting at all". In another apartment in Mirpur DOHS area, Dhaka, when the owner went to seek after-sales service from a solar installer, they found that the company did not exist anymore. "The company disappeared after two years," said Sazzad Hossain, a retired military officer and an owner of a flat. "*After that, I wanted to pay for servicing from another company, but they said it would cost me 30,000 tk for the service. Frustrated, I decided not to go for any service - who knows how long this company will exist?"*

Figure 8:9 Out of service solar panels Source: Author

However, instability and the fleeting existence of solar technology businesses often pushes consumers toward frustration and makes solar energy unpopular among those who wanted to use it. A solar energy system comprises a number of products that come with a warranty. For instance, a battery has 3-5 years, and a solar panel typically has a 20-25 years warranty; it is expected that consumers would get a replacement or after-sales servicing if any technical fault occurs within this warranty period. However, due to the instability of the businesses, it is difficult get services from the providers. Thus, a lack of maintenance and repair services means the system goes out of service and eventually the solar technology becomes useless to the urban high-rise dwellers.

8.5.3 Lack of knowledge and monitoring services

Lack of knowledge and control over standards of solar technology products are also responsible for making solar energy unpopular in on-grid areas. As we have seen in earlier sections, solar policy is seen as an easy solution for the problem of the severe electricity crisis. A number of initiatives were put in place to encourage consumers to use solar technology to reduce pressure on electricity consumption. However, there is a drawback to this policy in that there was never a provision to monitor the programme. Many respondents believe illegal practices arose because there were no consumer protection duties. The high-rise dwellers that I talked to state the policy is an unfair burden on them. Some of the respondents told me that apartment buyers were interested in finding an alternative: either buying old apartments or bribing different officials in BPDB. According to Atik Sobhan, the manager of Sanmar Properties, "*officials of DESCO (Dhaka Electric Supply Company Limited) or DESA (Dhaka Power Distribution Company) are mainly destroying the prospect of solar energy in Bangladesh. From top to bottom, everyone is corrupt".* With different ranges of bribery, the officials of DESCO or DESA sell a certificate which states either that 'the building doesn't require solar' or 'ask to install a smaller solar (PV) system'. Lack of monitoring provision after getting an electricity connection created an opportunity for illegitimate actions, such as a solar energy system from the retail market, changing the information sticker (discussed in chapter five), and selling cheap and low standard products without warranties. Many developers even offer the client an option of relocating the solar system from construction site to site after the completion of one construction site, and the client will not need to pay extra money for solar.

Untrained personnel in charge of solar technology dissemination came to light several times in different interviews. Ridwan Khan, the owner of New Solar Ltd, admits: *"on the day the urban solar policy was published, more than 30 employees resigned from our company and started their own solar business. I think on that day more than 300 solar companies were registered as solar business entities".* However concerns were raised about the lack of skilled installers, even in the BPDB do not have installers who understand solar technology and can measure the efficiency and outcome of solar panels, or identify problems with systems. According to Robiul Islam, an employee of Amicus Properties, "*people from DESA (Dhaka Power Distribution Company) and DESCO (Dhaka Electric Supply Company Limited) come with a measurement tape, count the solar cell numbers and write a certificate…by measuring the size with tape, no one can tell actual efficiency of a solar panel".*

As the above section demonstrates, solar energy policy and practice falls due to the lack of a holistic approach to the integration of the technology with the urban landscape.

8.6 Conclusion

This chapter demonstrated how the spatiality of Dhaka city's energy landscape has shaped the process of solar energy transition in the urban rooftop environment. I began the chapter by exploring how an electricity crisis was the main driver of the emergence of solar energy policy in on-grid areas. The chapter argued that the discourse of the electricity crisis played a vital role in bringing rooftop solar energy policy to urban areas. The policy was implemented by multiple actors pursuing different interests, such as the government fulfilling their political agenda, and private sector property developers and NGOs expanding their business in on-grid areas. The chapter has identified a number of socio-technological barriers which are spatiality constructed and shaped the transition of solar energy in on-grid areas.

The chapter revealed how the way solar energy was brought to the urban areas was not welcomed by urban residents. Although a number of symbolic events were organised by government, these failed to change peoples' mind-sets. Secondly, by engaging with the materiality of solar technology and electricity consumption in urban areas, the chapter argued that, due to a high level of electricity consumption and low generation capacity, solar energy does not make a significant contribution in urban life. By engaging with everyday urban energy use, this chapter revealed how solar energy becomes politicised on a more locally contingent. Agreeing with Ruthford (2016) the chapter argues there is also a need to link this strategic, discursive level of infrastructure politics to more consideration of everyday life. The largely invisible character of solar technology led users to forget its existence in their environment. Lastly, the chapter argued that a lack of knowledge and sufficient monitoring systems on the part of the power and energy authority, together with unstable market conditions, pushed users to lose interest on this technology.

This chapter contributes to the energy geography literature two ways. Firstly, it brings a city-specific case study to the literature of energy transition, where I present a Dhaka city's roles as context, constituent and consequence of the urban energy system that continually changes. The second contribution lies in bringing a city specific case from the global south, a part of the world that is hugely underrepresented in energy transition literature.

Chapter Nine: Conclusion

Figure 9:1 Assembling a solar panel

9.1 Introduction

The main objective of this thesis has been to understand the rollout of solar energy technology in Bangladesh and the consequences of this rollout for the everyday lives of on-grid and off-grid households. Drawing on recent debates regarding a 'spatial turn' in social science research on energy, this research has offered a geographically-informed perspective on the process of solar energy transition, showing how it involves a reconfiguration of current patterns and scales of economic and social activity (Bridge et al. 2013). In this thesis I have identified how the current literature on energy transition falls short in order to connect three critical elements of energy transition: energy policy, energy markets and lived experience of energy users. In this thesis I have argued that energy scholars need to pay more attention to the links among these three crucial elements as they are inter-connected elements for any energy transition. In making my argument, I have also drawn on the literatures on everyday life, post-development and political economy which, together, have provided theoretical and conceptual support for its analytical focus on the roll-out of solar energy technology. The empirical work underpinning the thesis has paid particular attention to spatial differences in the social practices and experiences of various forms of photovoltaic solar energy technology in on-grid and off-grid areas. I have emphasised the geographical situated-ness of the various energy landscapes, highlighted the everyday experience of living with solar-PV, and introduced the voices and aspirations of energy users who are absent in many scholarly accounts of energy transition. In these ways this study addresses significant gaps in the current literature, and contributed to energy scholarship by connecting both 'ends' of the solar technology transition: it examines the various energy policies, actors, logics and practices through which a market for solar has been constituted in Bangladesh, and analyses the implications of these policies and practices for end users in rural and urban areas.

In this final chapter I synthesise key findings of the thesis and highlight its significant empirical and conceptual contributions. Specifically, it demonstrates how this study expands current understandings of the solar energy transition in Bangladesh, and the practices and user-experiences of solar energy technologies in off-grid and on-grid areas of the Global South. This concluding chapter is divided into five sections: following this introduction, the chapter revisits the research questions and outlines how its findings answer those questions (Section 9.2). The chapter then moves to highlight the key contribution of this thesis (Section 9.3). Section 9.4 then discusses the challenges and limitations of the study, followed by a section outlining some future research possibilities (Section 9.5).

9.2 Revisiting the Research Questions

The central focus of this research has been to understand the rollout of solar energy in Bangladesh and the social consequences of the country's solar energy transition. With this broad objective in mind, three research questions were set at the beginning of this research.

RQ 1. How does solar-PV emerge - and subsequently roll out - as an alternative source of electricity supply in the power and energy sector in Bangladesh?

The first research question examined the political processes and practices surrounding the emergence of solar energy and its roll out as an alternative source of electrical power supply and lighting in the energy sector in Bangladesh. To answer this question, Chapter Four (entitled 'Power and Energy Sector Reforms: Emergence of Solar Energy in Bangladesh') and Chapter Five ('Making a Market for Solar Energy Technology'), explored the historical background of solar energy in Bangladesh. More specifically, based on documentary evidence regarding reform processes to the power and energy sector in Bangladesh, in this chapter I engaged the political economy literature and contextualised the emergence of solar energy technology as an alternative source of electricity supply. Here I explained how influenced by international donor organisations and domestic political concerns, the power sector has been systematically reformed and privatised during the neoliberalisation of the public sector in the late 80s. Since the late 80s, a number of policies have been reformed, opening a door to multiple private actors to become part of this sector. Through tracing the historical and contemporary dynamics of electricity generation, distribution and consumption, I conclude that Bangladesh's electricity sector has been influenced profoundly by the interplay of global energy discourses around Sustainable Energy for All and national political shifts.

Chapter Five ('Making a Market for Solar Energy Technology') argued that the discourse of a domestic electricity crisis, characterised by chronic shortages of supply relative to demand, has played a significant role in accelerating the process of introducing solar energy technology in Bangladesh, and as well as other developing countries. This chapter confirmed the findings of Cross (2013), who argues that markets for solar energy do not just emerge: they are made, through the interplay of ideas, logic, knowledge and practices. Building upon the broader political-economic overview of the power and energy sector in Chapter Four, in this chapter I analysed the growth of the solar energy market in Bangladesh since the late 90s. I explained how a small number of leading micro-finance NGOs adopted the solar home system programme as a part of their economic development programme. By giving access to solar electricity, these NGOs' targeted the rural poor as clients of solar energy products, with clients taking a loan for income generative activities for economic development. With the launch of

the World Bank's RERED programme, the diffusion of solar energy technology has accelerated, and a market-based approach and neoliberal motif has shaped the solar energy programme over the time in Bangladesh. In addition, the logic of a national electricity crisis in on-grid areas has been used to introduce solar energy to these on-grid areas: a national rooftop solar energy policy has inspired various actors to participate in this burgeoning field.

Chapter Five explored how the market model for solar was brought together with funding mechanisms (via the World Bank and IDCOL), and examined the consequences of this market making process on everyday practices in the energy sector. Here I analysed the evolving role of different actors - such as the state international donor agencies, NGOs and private organisations – in making and mediating a market for solar energy in Bangladesh; and how different ideas, rationales and discourses have facilitated the roll out of solar energy technology in the country. In this chapter I explained how the solar home system programme in off-grid areas has successfully developed a large solar energy market, although this been accompanied by negative impacts on the quality of the solar technology product and service to customers. The chapter showed that detaching the market model from spatially-shaped market practices by the multi-scaler actors ignores the complex political and social realities of a country's energy market. Inspired by post-development scholars (such as Ferguson, 1992; Escobar, 1994; Ziai, 2013; Schaaf, 2013), in this chapter, I argued that the way the development industry constructs energy problems (energy shortage for economic development), perceives solutions (creating a solar market) and brings forward technical solution (allowing private actors) for the sustainability the energy programme overlooks relations of power, conflicts of interest, and everyday market politics at both global and national scales.

The research adds to the literature by showing how the emergence of solar-PV technology in Bangladesh is an outcome of international donor organisations and domestic political concerns, where discourse of energy crisis and economic development have played a dominant role. Through tracing the historical perspective and contemporary dynamic of energy sector reforms and solar energy market creation in Bangladesh, the research highlights the complex relationships between multiple actors in energy sector and, spatial aspects of this relationship. In these ways it contributes to an emerging literature on the political economy of energy transition through the example of a low carbon energy transition in the Global South.

RQ 2. How do people in on-grid and off-grid areas integrate solar energy into their everyday life?

The second research question was explored in Chapter Six ('Life in an off-grid area') and Chapter Eight ('Solar Energy on urban rooftops'). It sought to understand user experiences of solar energy technology and its implications for everyday life in both on-grid and off-grid areas. Here I demonstrated that geographical location makes a significant difference in integrating solar energy in rural and urban areas because of the geographical situated-ness, availability of other energy sources, various provisions of energy access, and the social life of a particular space such as a rooftop in urban areas. These two chapters show how spatial differences at the sub-national scale – i.e. the difference between urban and rural areas - shapes the process of solar energy transition and user experience. Chapter Six and Chapter Eight found that the way solar energy is integrated within everyday life does not replace other sources of electricity or lighting due to the limited capacities of solar energy technology. Despite the integration of solar energy technology in on-grid and off-grid households, other sources of supply were still required to meet the needs of daily energy use.

Chapter Six ('Life in an Off-grid Area') problematised the way the success of the solar energy programme is measured, by showing how measurements based on quantity of uptake overlook the everyday struggles of end-users. Following the day to day life of people who live in the off-grid villages on Sandwip, this research identified how access to solar electricity and access to grid electricity have a different meaning for the end users. Specifically, people in Sandwip do not consider solar electricity as "proper electricity". Several reasons were identified why solar energy is considered inferior to grid electricity and how, as a consequence, it fails to meet the needs of rural off-grid inhabitants. The quote from Mrs Asma in Chapter Six sums this up: "*living with solar means you always need to plan your work, prioritise your need and justify your use, otherwise, you will be sitting in the dark".* This sentiment leads to a crucial question, highlighted by post-development scholarship: what is development and how should development be measured? Does access to a couple of light bulbs and connection to a mobile phone constitute progress?

In addition, Chapter Six also identified how the decision to adopt a solar energy technology is not straightforward as it is bound up in the political-economic and socio-cultural context of electricity. With financial help from international donor organisations, solar energy programmes have developed a mechanism to bring the solar energy technology as an alternative source of electricity via a system of credit. Here I argued that the programme has failed to give energy access for all as despite financial support, the price of solar energy technology is still beyond the capacity of a large share of population in off-grid areas in Bangladesh. This failure raises the important question of the motives driving key actors in a solar energy transition in the Global South and how these motives affect the pattern, rate and

extent of uptake. Thus, in this chapter I call upon energy geographers whose work is located in the Global South to engage with more than the quantitative issues surrounding new technology deployment (e.g. the number of households served). It suggests, rather, the importance of qualitative assessments of where, how and by whom solar is taken up and of focussing on everyday lives in a given context and location.

In Chapter Eight ('Solar Energy on Urban Rooftops') I showed how people in on-grid areas integrate solar energy into their everyday life by focusing on the specific case of urban rooftop policy. It explored the 'endogenous' and 'exogenous' factors driving uptake: from the regulatory context to the practices of energy use and the systems of provision (Castán-Broto, 2017:107) that have shaped the solar energy transition in on-grid areas in Bangladesh. The provision of solar energy technology had appeared in on-grid areas to solve a national electricity supply crisis. This chapter identified spatial, economic and socio-technical barriers shaping the transition of solar energy technology in on-grid areas. Although a number of symbolic events were organised by the government, these failed to contribute any positive impact on peoples' mind-sets. In this chapter I also presented how solar energy does not make a significant contribution to urban life in on-grid areas were other forms of electricity are available, due to relatively high levels of electricity consumption in these areas and the low generation capacity of solar energy technology. Here I argued that a lack of knowledge and sufficient monitoring systems on the part of the power and energy authority, together with unstable market conditions, had made solar energy unwanted in on-grid areas.

The 'successes' of solar energy programme in the global south are typically framed around the establishment and strengthening of the solar infrastructure, rather than being viewed from the perspective of the households ultimately using the technology (Gent, 2014). Thus, by following the mundane activities of off-grid lives, this research contributes a nuanced understanding of the everyday life and daily struggle over access to energy in off-grid areas in the Global South. The study simultaneously brings a community perspective (Campbell et al. 2016) to debates on energy crisis and takes a closer look at the transition towards low carbon energy within urban areas, thereby contributing to areas of research were experiences of cities in the global south are under-represented (Castán-Broto et al. 2017).

RQ 3. To what extent do solar energy interventions work to achieve particular goals of development?

The answer to this third research question can be found throughout the thesis, although Chapter Seven (Solar Energy Transition for Rural Development) was dedicated to

understanding the impact of solar energy interventions in rural development. Through examining the perspectives, voices and aspirations of low carbon energy users, this chapter contributed to nascent but growing body of literature on user-experiences that shows how the implications of solar energy technologies are far from guaranteed. Two critical aspects were revealed as an outcome of this chapter: first, the chapter demonstrated that claims by solar advocates - such as the state, donor agencies and NGOs, and private companies - to justify dissemination of solar energy technology are partially correct; secondly, the solar energy programmes in Bangladesh have failed to recognise the heterogeneity of needs of off-grid people and, in so doing, have overlooked the significance of class and gender in the transition and development of Bangladesh's solar technology programme.

This study has confirmed that the impacts of solar energy transition in off-grid areas are usually positive, although limited. In this thesis I have demonstrated that neither SHS nor solar mini-grid makes much of a contribution toward poverty alleviation. Due to their higher tariffs, both of the solar energy technologies (solar home system and solar mini grid) are used by rural middle-class people. In addition, limited-hour energy backup and a restricted number of appliances have made solar energy unsuitable for income generative activities. Thus, the thesis concludes that solar energy technology intervention provides important 'non-monetary lifestyle benefits' (Wamukonya, 2007; Komatsu et al., 2011) such as increased levels of comfort, security, connection and entertainment.

Gender has emerged as an important theme for this research. The chapter confirmed similarities and differences in the experiences, perceptions, and realities of male and female users of solar technology. Solar electricity has created a sense of security and connectivity, via lights, mobile phone and television. In this thesis I argued that the way development advocates characterise poor people's needs fails to acknowledge the heterogeneity of people's social development needs. For example, the contrast between solar home system technology and solar mini-grid technology's brighter light and capacity to run heavy-load machinery in the marketplace confirms the social hierarchy of men's and women's work. I also argued that different forms of solar technologies not only reproduce a stereotypical division of labour between men and women, but it also reinforces gender disparities in access to resources and services.

The main goal of solar energy intervention in on-grid areas was to reduce the electricity crisis. The discourse of an electricity crisis played a vital role in bringing rooftop solar energy policy to urban areas. The policy was implemented by multiple actors pursuing different interests, such as the government fulfilling their political agenda, and private sector property developers and NGOs expanding their business in on-grid areas. The chapter has identified a number of

barriers that explain the failure of the urban rooftop solar technology policy, such as economic, socio-technical and spatial. The study revealed how in high rise buildings finding an appropriate connection to a device, or to uses that would get maximum benefit from solar technology, was difficult because of the availability of other sources of electricity. Besides, the study showed how solar energy technology failed to materialise on urban rooftops because of the way rooftops have a social life in cities in Bangladesh. Multiple uses of a rooftop leave little space for the installation of solar technology, and this has limited its contribution in urban everyday life. Finally, due to the lack of a service network and the instability of solar technology businesses, users find it difficult to carry on using solar technology once the system breaks down. Chapter Eight concluded that the intervention of solar energy technology in the on-grid area has, in practice, had no such impact toward the national electricity crisis.

9.3 Contribution of the thesis

The overarching contribution of this research is to understand the practices and consequences of solar energy transition in Bangladesh. The primary contribution of this doctoral thesis are its field-based insights into spatial differences (urban vs. rural) in the experience of solar energy transition and the complex relations of multi-scalar actors who are actively involved in this process of transition. To my knowledge, very few researchers have sought to understand the significance of spatial differences on energy transition within the same study. Until now, not many researchers have examined empirically the spatial processes of energy transition in on-grid and off-grid areas simultaneously. Through its grounded investigation of solar programmes in Bangladesh, this research makes three types of contribution to knowledge and understanding. Schematically these are (a) a contribution to the social science literature on energy and development; (b) an empirical contribution to debates about energy access (c) a methodological contribution. Each of these contributions is elaborated below.

Contribution to the Social Science Literature on Energy and Development

This thesis has contributed to several fields of social science and, specifically, to work on energy transition, critical development studies and gender studies. Firstly, this research has contributed to the literature on energy transition by demonstrating how the experience of energy transition is spatially differentiated. The low-carbon energy transition in the Global South is one of several neglected areas of research in energy geography. While much has written about the experiences of low carbon energy transition in the Global North, only a few have written about the experiences in the Global South. There is nascent but growing interest within the field of energy geographies in understanding the spatiality of energy transition (see

Bridge et al. 2013; Bridge, 2017; Castán-Broto and Baker, 2017; Baker, 2017; McEwan, 2017). Using the conceptual framework of energy transition as a "geographically constituted process" (Bridge et al. 2013), this research has explored a dialectical relationship between space, place and energy interventions. Thus, in this thesis I have adopted a spatially-sensitive approach – focused on urban/rural differentiation, cross-scale processes, and place-based characteristics - to understanding the process of energy transition.

This thesis is written based on very specific experiences of solar energy transition in Bangladesh. This literature that narrates the experiences of low carbon energy transition in the Global South mostly explored the experiences of rural or off-grid areas (See Turner, 2015, Kumar, 2015, Gent, 2014). By contrast, very little has shown the experiences of low carbon energy transition in urban or on-grid areas in the Global South (although see Castán-Broto et al. 2017, Luque-Ayala, 2012). This study is distinctive and makes an original contribution by including experiences of solar energy intervention in both rural (off-grid) and on urban (on-grid) areas and showing how different energy landscapes have shaped the solar energy transition in Bangladesh. In this way the study also contributes to work on the political economy of energy transition, by showing the complex and multi-scalar relationships between global and national actors and how these combines in order to achieve a shared development agenda.

The study contributes to critical development studies by identifying the multiple scales and spaces through which solar energy transition takes place. In this study I have showed how the marriage between a global development agenda (SDG#7) and a national agenda (Electricity for All) has shaped energy policy in Bangladesh and created space for solar energy to solve the energy crisis in Bangladesh. I have argued that this marriage opens a door for a wide range of multi-scalar actors and spaces, such as international actors (donor organisations), national actors (state-NGOs-private organisations), the macro-space of an energy market and the micro-spaces of the home. Recognising multiple-scales, this thesis has contributed to questioning the influence of individual actors and the power relationships among various actors. By making connections between energy reform and policy and end users through the process of market creation, this study gathers an in-depth knowledge about the power relationships between various actors, and who gains and who loses in the process of solar technology intervention in domestic lives.

In this thesis I have identified that gender is an understudied aspect in the energy transition literature. The studies that engaged with gender analysis in energy policy and energy access studies in the Global South, have focused mainly on cooking energy (Cecelski 1992, Skutsch 1995, Dutta 2003, Miller and Mobarak 2013) and a handful of studies examine the impact of electricity on women empowerment (Winther 2011, 2015; Winther et al. 2017). The emphasis on gender analysis in this doctoral research has allowed it to understand the similarities and differences in the experiences, perceptions, and realities of both male and female users of solar technology. Findings of this study show that different forms of solar technologies reproduce a stereotypical division of labour between men and women, and also reinforce gender disparities in access to resources and services. Through this research, I contribute to gender studies using the specific case of solar energy provision in the Global South.

Empirical Contribution

The thesis makes three empirical contributions. First, it explains the political economy of solar rollout in Bangladesh. Second, it reveals the lived impact of solar in on and off grid settings i.e. how people in off-grid and on-grid live with solar energy. Third, it draws out the experience of solar energy transition in Bangladesh and identifies what it can tell us about dominant 'development imaginaries' of solar energy and realities on the ground. The following section explains these empirical contributions of the thesis.

The political economy of solar rollout in Bangladesh

The first empirical contribution of this thesis is its presentation of the political economy of solar rollout in Bangladesh. This thesis documents the evolution of electricity provision and describes the current state of the power and energy sector in Bangladesh. The thesis explains in detail the complex relationship between the actors, devices and social relations that constitute a market for solar energy, and the continuous changes within it that have been shaping the uptake of solar home systems and the solar transition more generally in Bangladesh. I argue this shift was rooted in wider economic policy shifts and transmitted through policy led assistance from international development organisations. In the thesis we see, Sustainable Development Goals (SDG#7), and an influx of associated funding for low carbon energy, the solar energy has been positioned as a primary means to achieve the development. The thesis also narrates how international donor agencies play vital role influencing the government to reform the energy policy and how a market-led approach has become the main driver for economic development in the energy sector. It explains to the reader how these reforms have changed the relationship between the state, civil society and

private organisations and the complex array of knowledge practices, social relationships and meanings of the solar energy technology market.

In the thesis I explain that how the initiatives that solar advocates have taken have failed to acknowledge the complex relationships of a market that is spatially constituted, and is shaped by the political and social realities of the country (Ferguson 1994). The thesis identifies a significant number of obstacles such as a lack of support for the local solar producers, lack of monitory system to control the standard of solar products make this burgeoning market unstable. The thesis also tells the current mechanisms that solar advocates have developed and implemented failed to reach the bottom of the pyramid (cf, Prahald, 2010). There is a need for policies that target the uptake of solar as part of national or international agendas around sustainable energy for all to ensure their financial mechanisms enable this goal to be met.

The lived impact of solar in on-grid and off-grid settings

The strength of this research is the detailed and rich ethnographic insight of the lived impact of solar in on-grid and off grid settings. There is a dearth of information relating to the actual lived experience of users with solar energy technology (Neiwenhout et al. 2001, Cherni, 2008). This thesis stresses there is an urgent need for greater evidence to be uncovered on the experiences of low crabon energy technology interventions to determine whether technologies are fulfilling the practical energy needs and priorities of users. The thesis documents the everyday lived experiences of off-grid people who live in a geographically formidable area (Sandwip Island) and on-grid people who live in urban areas where energy services are easily available (Dhaka metropolitan). In exploring the everyday life of solar energy users, this thesis reveals the aspirations, experiences, and needs of people who live in on-grid and off-grid areas in Bangladesh and how they manage their everyday energy needs. Placing the end user at the centre of analysis, this study contributes to a new empirical insight to debates over end-users' experiences with small scale solar energy technology in developing countries.

In this thesis we see although solar energy in off-grid areas has been delivered as a means to give electricity access on Sandwip, the technology is not perceived as electricity by the community. The thesis reveals how access to electricity is understood to mean the freedom of using various electronic devices and having flexibility in an individual's routine. The limited capacity of solar technology used in Sandwip does not provide either of these freedoms, and so makes solar electricity inferior to grid electricity. The thesis offers a mean of questioning the capacity of solar energy technology to meet people's need. Everyday life of solar energy

users reveals although the solar energy technology brought lights to homes and allowed the residents of off-grid areas to run small home appliances like mobile phone, radio, television, it failed to provide medical facilities in their lives. Similarly, solar energy in on-grid areas had failed to provide any benefit to the people who are already been connected with national grid. Limited capacity and high price make solar energy technology unpopular in both energy landscapes.

In this thesis we also see despite financial support from IDCOL, the price of solar energy home systems is still beyond the capacity of many inhabitants in off-grid areas. In addition, the tariff for solar electricity is 6-8 times higher than the tariff from national grid electricity. On the other hand, solar energy technology in urban areas did not receive any financial support from the government or international organisation. Solar energy users in urban areas did not find any significant benefit regardless of spending a huge amount of money for the solar installations as it has very limited output for an individual family. The thesis concludes the decision to adopt a solar energy technology is not a straightforward one for the end users. It is, rather, bound up in the political-economic and socio-cultural context of electricity.

The *experience of solar energy transition in Bangladesh and narratives about dominant 'development imaginaries' of solar energy*

The third contribution of the thesis it reveals the experience of solar energy transition in Bangladesh tell us about dominant 'development imaginaries' of solar energy. The thesis confirms how the narrative of solar energy for rural development is a powerful social imaginary that materialises both an ethic of care and an ethic of commercial interest (see Cross, 2013). Solar technology is a popular a brand name commodity that successfully assembles a wide array of concerns and interests, politics, moralities and ethics. In the second chapter (literature review), we see the dominant narratives around solar energy technology is it a life-altering device for accelerating development by providing income generation opportunities, reducing the costs of fuel such as kerosene, reducing pollution, reducing work for women who have to clean kerosene lamps (Barua, 2001, Komatsu et al., 2011; Mondal and Klein, 2011. The thesis argues the way the solar energy programme has been looked at and its success measured (through the number of solar technology installations and value of kerosene saved), over-shadows the everyday struggles of those living in off-grid areas with limited access to electricity. I argue here that simply focusing on numbers ignores the everyday realities of those people who do not have access to electricity and their resultant needs and difficulties. The

focus on the everyday life solar of solar energy users challenges this dominant development imaginaries and contributes a new knowledge to existing research on energy transitions and development.

The thesis highlights two critical aspects of solar energy transition and dominant development imaginaries. Firstly, the findings demonstrate that, while the claims made by solar advocates such as the state, donor agencies and NGOs, and private companies to justify dissemination of solar energy technology are partially true, these claims fail to capture the bigger picture of everyday life for off-grid populations. Secondly, solar energy programmes in Bangladesh have failed to recognise the heterogeneous needs of off-grid people and, as a result, overlook the value of class and gender analyses and the vital role these can play in the adoption and development of solar technology programme. This study criticises energy policy approaches that tend to see communities as homogeneous entities. This can overlook complex realities where access to and control over energy resources vary by multiple, interlocking and hierarchical systems of differentiation. While the implications of energy access are clearly gendered, as seen in this research, energy policy in regard to solar roll out in Bangladesh does not refer to this issue. Therefore, project planners and policymakers need to think critically about the differences between various social groups and how the effects of the projects vary for them. By doing so, this research recommends a need d to move beyond standardised ‘wholesale’ ‘models’ of energy delivery by acknowledging the heterogeneity of energy needs based on physical and social location.

The research also highly recommends policy makers take a step back and revise their energy policy by adding some simple interrogating questions, asking ‘What’ and ‘for Who’, rather simply following a route to answer How? If energy policy only focuses on achieving ‘How’, it will miss the most important feature of energy transition: human needs. Who benefits, and who does not, and why can be understood by adopting ethnographic approaches to research. Inclusive and active participation of end-users or communities is critical for democratic development in the long run. Enhancing meaningful involvement of end users can improve the durability of any development programme.

Methodological Contribution to Energy Research

The spatial difference of energy transition in rural and urban has enabled this research to show the vital role of spatial difference in the experience and potential of solar energy for development. This research highly encourages other energy scholars to explore the spatial difference of various energy landscapes within the same country. In addition to this, as we

have seen in this thesis, current energy policies are overwhelmingly technology-driven and have a technocratic emphasis in energy provision. This research has demonstrated that a policy focus on energy as a technical or technology problem fails to acknowledge the social issues involved in energy access, use, and control and mostly importantly people. This research recommends a people-centred approach (See Castán-Broto et al., 2017) for energy transition research to understand the process and meanings of energy transition, people's experiences of energy intervention, as well as the relationships between structure, agency and geographic context (Hebert, 2000).

For doing people-centred energy transition research, this study highly endorsed an ethnographic approach. The advantage of adopting an ethnographic approach is that it is fluid and flexible, meaning a researcher can constantly adjust and reflect on the data being gathered. In this research I argue the transition of low carbon energy in the Global South involves not only multi-scale local and global actors but also a flow of discourse, ideas, power and resources. Consequently, an open-ended approach to research is valuable, allowing for ethnographic research to be complemented successfully with a whole suite of methods including several field sites. Instead of starting with a set hypothesis to test, ethnographic research helps laying out a theoretical problem or question that guides the evolving design and process of the research (Smith and High, 2017). The thesis demonstrated that issues like the gendered, heterogeneity of needs and the activities of everyday life can be revealed via an open-ended ethnographic approach. Recognising the significance of everyday and micro-politics in energy transition, researchers are increasingly using an ethnographic approach to research energy in order to understand detailed information about energy transition (Kumar, 2015, Tuner, 2015, Luque-Ayala, 2012)

9.4 Limitation and Challenges

This section presents the limitations and challenges faced during the research which shaped the thesis:

This research has acknowledged the value of undertaking an open-ended ethnographic approach to understand the multi-scalar relations, practices and experiences associated with the solar energy transition in Bangladesh. I have argued that the existence of multiple actors operating at multiple scales puts a researcher in a difficult position when one has a limited period to explore an extensive network. As I mentioned in Chapter Three, researching the low-energy transition in the Global South includes not only multi-scale local and global actors but also a cross-scalar flow of discourses, ideas, power and resources (Cross, 2013). Bebbington

and Kothari (2004) have identified a similar analytical problem in some development-focused research, where the location of this work is not based on a single organisation or bounded localities. The network map (see page 40) that I developed served as a guiding tool in undertaking the research (see Chapter Three). Understating low carbon energy transition, therefore, requires a relational conception of space (Castán-Broto, 2017) that involves not only a variety of local actors, but also a wide range of international actors together with a cross-scale flow of ideas, logic, practices, technologies and devices. The network map gave an overall idea to capture the diverse range of actors in this multi-scalar network.

The fluid and flexible mode of enquiry helped me to change my direction according to the field. However, here I must admit investigating this wide network was difficult in a short duration. Furthermore, studying everyday life is a complicated job, as it contains "a diversity in ordering, sequencing and frequency" (Shove et al. 2009: 4 cited in Kumar, 2015). Using McFarlane's (2011) work, Kumar suggests "following actors and 'close study of particular sites' concerning 'multiple space-times' can help methodologically operationalise assemblage thinking" (Kumar, 2015, p 289). At the end of this study if I reflect and think critically what I have learnt from this process, I believe I would have had a richer understanding of everyday life of solar energy users if I could have spent more time in Sandwip and following everyday life more rigorously in different seasons.

Here I want to mention that energy performance of solar energy technology is different in different seasons. For example, in the season of the monsoon, the performance of solar energy electricity generation can drop due to cloud cover. Also, energy consumption can change with the variation of season. Some of the respondents mentioned that due to heavy rain during monsoon people tend to stay at home. The use of day light (See Chapter Six) also becomes limited during the monsoon. Limited time in the field did not allow this research to directly explore variation in user experiences across the seasonal cycle. Some of these issues did appear in several interviews on Sandwip, such as the way the performance of solar energy technology can drop considerably during the monsoon as well as in winter (See Chowdhury et al. 2009). In several conversations, the respondents mentioned how it is very difficult to cope with limited energy supply especially in monsoon season when people are immobile for heavy rain. In addition, in Chapter Six I have explained how the Purobi mini grid struggles to cope with the excessive demand for electricity supply in the heat of the summer (See Khan, 2015) when people use electricity to run fans and refrigeration. Therefore, I believe an in-depth analysis of solar energy use and practice over the various seasons could have enriched this research with an additional temporal dimension.

9.5 Future Research Paths

There are several research avenues can be recommended for future investigation. This study has presented the spatial experiences of solar energy technology integration and users experiences in two specific geographical areas: Dhaka (on-grid) and Sandwip (off-grid). For future investigation, I believe another geographical location could add another spatial experiences for energy literature. Nonetheless, this section discusses three areas of future research that emerge out of this thesis. Firstly, a study on solar energy market after 2018 when the World Bank and other donor organisation stops funding the solar home system programme. In Chapter Five, this thesis flagged up that both the solar experts and the international donor organisations believed that the market for solar energy has grown independently without any financial support. Therefore, this research recommends a post-funding investigation to understand the economic sustainability of the solar energy market and its implications for the continued uptake of solar.

Secondly, this research explored mainly the experience of domestic users and some non-domestic user in Sandwip. However, there are a number of solar energy programmes funded by international donor organisations that are aimed at commercial (i.e. non-domestic) users such as solar mini-grid, solar irrigation pump. Until now IDCOL has approved 18 Solar Mini-Grid Projects and 629 solar irrigation pumps of which 607 are already in operation[54]. According to the IDCOL website, IDCOL has a target to provide fund 50 solar mini-grids by 2018. Therefore, studies on the non-domestic usage of solar energy will enhance the knowledge energy literature. In addition, during the fieldwork, I learnt from a leading international donor organisation that they are seeking an alternative mechanism to reach bottom of the pyramid via Pico-solar lamp. Thus, the study suggests exploring the future intervention that appeared to be an alternative to the current energy transitions mechanism.

A very crucial area of investigation is solar energy technology waste. The thesis has highlighted the intervention of solar energy technology has created a massive market. The scale of this market has consequences for the production of e-waste (Chapter Five). So far the literature on solar energy intervention in the Global South mostly focuses on the dissemination of the technology, with hardly any literature expressing concern about the impact of solar technology e-waste and its consequences on the environment (see, however, Mulvaney 2013, 2014). At the time I was doing fieldwork I learned that 65,000 solar home systems were sold every month under IDCOL's solar home programme. In addition, there is a large retail market selling solar energy devices that could add another 20,000 solar home

[54] http://idcol.org/home/solar_min

system installations every month. It has been nearly two decades that solar energy is used for rural electrification and, therefore, this thesis recommends an investigation on solar energy technology waste on an urgent basis.

These are the several opportunities for further on energy transition in the Global South, and particularly in Bangladesh. I believe there are plenty of opportunities for doing further research to explore the spatial differences and everyday practices of various kinds of energy provision in different locations. In-depth engagement with an ethnographic approach will help energy practitioners and policy makers come up with more rigorous, sustainable energy policy to address the global challenges of climate change and energy access.

9.6 Conclusion

In this concluding section, I want to highlight some issues that emerged from this thesis that are important for scholars to note in future research on energy and development, as well as for further research on the low carbon energy transition in the Global South. Throughout this thesis, I have attempted to demonstrate the dialectical relationship between space, place and low carbon energy interventions. The thesis shows people accept, adapt and negotiate a change in energy provision, institutions, and challenges in a variety of ways, depending on their social and geographical locations. In this thesis I argue the importance of geographical situated-ness and materiality of low carbon energy provision are often overlooked in energy research in social science. Recognising the value of 'spatial turn' in social science research on energy along with other energy geographers (Bridge et al., 2013; Bridge, 2017; Castán-Broto & Baker, 2017), this research argues that a spatially-sensitive approach can enhance knowledge about energy transition. I also argue that together with the literature on political economy, post- development and everyday life, it can shape a critical understanding of energy transition. Attention to scale and spatiality are also highlighted in the importance of heeding not only various actors' heterogeneity and its implications, but also household-level and individual level decision-making relating to energy. In this respect, a greater focus on social differentiation through geographical location, the viability of energy sources, gender, class, age, and position in the household are essential in assessing the ways that energy comes to influence lives and livelihoods. Finally, this research calls upon other energy researchers to engage with more people focussed research using spatial understanding of energy transition to enhance the understanding of people's energy need.

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Bangladesh: Rural Electronification and Renewable Energy Project II (RERED II)

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Bangladesh- IDCOL Solar Home Systems Project
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Global Development Finance: Financing the Poorest Countries
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